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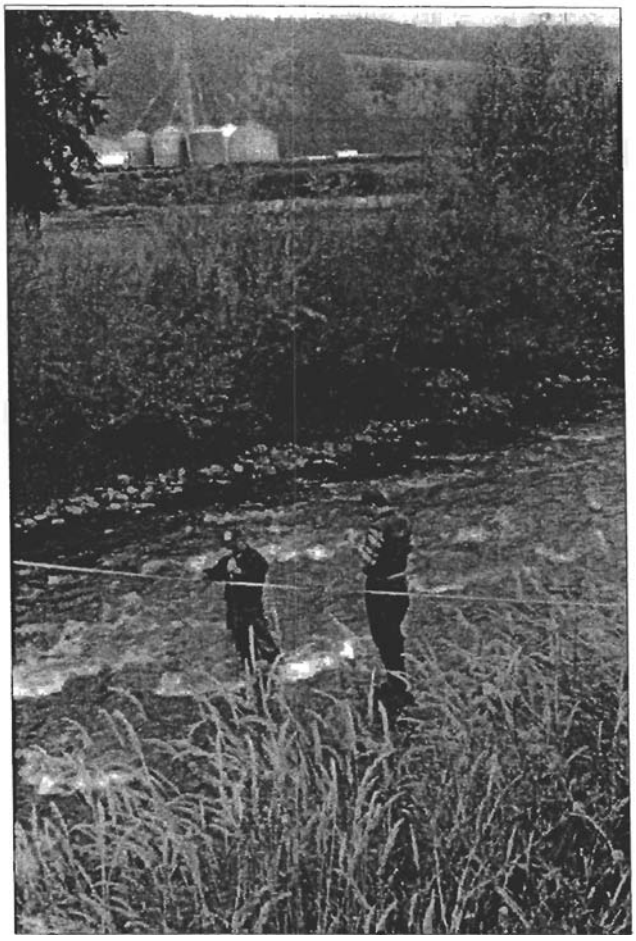

Lostine River Instream Flow Study

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EXECUTIVE SUMMARY

An instream flow study was conducted in four reaches of the Lostine River (Wallowa County, Oregon) between August 1995 and September 1996. This study was conducted to develop habitat versus flow relationships for key anadromous and resident fish species in this river. The species evaluated in this study included spring chinook salmon, early fall chinook salmon, steelhead trout, rainbow trout, and bull trout. In addition, habitat versus flow relationships were developed for coho salmon, a species which is presently extinct in the Snake River basin but which may be reintroduced in the future. Degraded habitat conditions are present in the lower two reaches of the Lostine River due to irrigation withdrawals during natural low flow periods of the year (i.e., August through October), by elevated water temperatures resulting from these low flow conditions, and by channelization. Flows in the lower reaches of the Lostine River may be reduced below 10 cfs by agricultural diversions during the late summer and early fall.

A total of 44 transects were established at 11 sites within the lower Lostine River. Hydraulic measurements were obtained at each transect during a low flow (50 cfs), a medium flow (100 cfs), and a high flow (1,000 cfs). A calibrated hydraulic model and habitat model using the Physical Habitat Simulation System (PHABSIM) was then developed to simulate habitat conditions in the Lostine River for flows ranging from 5 to 1,000 cfs. The habitat simulations were developed using suitability curves derived from site specific data and literature sources. Flows in the lower two reaches of the river were found to provide poor habitat conditions during August and September for spawning and juvenile chinook salmon, juvenile steelhead/rainbow trout, juvenile bull trout, and adult rainbow and bull trout. Low flows during these two months also inhibit the upstream migration of adult chinook salmon.

Based upon the instream flow analysis, minimum flows between 25 and 60 cfs are recommended for Reaches 1 and 2 of the Lostine River to provide an adequate level of habitat quantity and quality (i.e., 50 percent of maximum habitat value for key fish species and life stages). Minimum passage flows of 40 cfs are recommended to allow for successful passage of spring chinook and early fall chinook salmon through these reaches during the migration period of these fish.

1. INTRODUCTION

The Lostine River is located within the Grand Ronde River subbasin in northeastern Oregon, and is a tributary to the Wallowa River between Lostine and Wallowa, Oregon. Because of its connection to the Snake and Columbia rivers, the Lostine River presently provides habitat to two important anadromous fish species: spring chinook salmon (*Oncorhynchus tshawytscha*) and summer steelhead trout (*Oncorhynchus mykiss*) (ODFW 1990). Late fall chinook salmon are currently found only in very low numbers in the lower Grande Ronde River below the confluence with the Wenaha River (ODFW 1990). The Lostine and Wallowa rivers historically contained populations of coho salmon (*Oncorhynchus kisutch*) and early fall chinook salmon. Coho salmon were documented to be present in the lower 5 mi of the Lostine River during surveys conducted in 1957 (ODFW 1990). The population of coho salmon in the Lostine and Wallowa rivers drastically declined after 1978; this species has been considered extinct in the Snake River basin since 1986 (ODFW 1990). Early fall chinook salmon were present in the Grande Ronde River subbasin at the turn of the century (Bryson 1987), and a remnant of this population was thought to be present in the Lostine River during a survey conducted in 1960 (Thompson and Haas 1960). In addition to anadromous fish, several important resident fish species, including rainbow trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*) reside in the Lostine River. Cutthroat trout (*Oncorhynchus clarki*) are present in the Lostine River, although their distribution is limited to the headwaters. This species is presently stocked in Francis Lake, which drains into a tributary of the upper Lostine River.

Fish habitat in the Lostine River has been adversely impacted by irrigation diversions, channelization, and degradation of riparian habitat. Irrigation diversions result in reductions in streamflow and degradation of water quality, including increases in water temperature, during late summer and early fall (ODFW 1990; Kostow 1995). The lower Lostine River from the confluence of the Wallowa River to the Westside Ditch is presently on the Oregon Department of Environmental Quality's 303(d) list, which is used to identify water quality limited streams within the state. This section of the river (Segment 31E-LOT0) was listed because of: 1) reduced flows and dewatering caused by agricultural diversions; 2) habitat modification impacts caused by channelization; and 3) sediment impacts. Reductions in streamflow and channelization have the greatest impacts on anadromous and resident fish in the lower Lostine River. Numerous agricultural diversions are present in this section of the river; diversions of water result in periods

of extremely low flows from August through October. Channelization is evident in many sections of the lower Lostine River, especially between the confluence with the Wallowa River and the town of Lostine, and in sections of the river located just south of this town (Figure 1-1).

Fish populations in the Lostine River were historically impacted by entrainment of fry and juveniles into unscreened irrigation ditches located in the lower river (ODFW 1990). All irrigation diversions on the Lostine river now possess screens to minimize entrainment losses.

1.1 FISH RESOURCES

The Grande Ronde River historically possessed large runs of native anadromous fish, including chinook salmon, summer steelhead trout, coho salmon, and sockeye salmon (ODFW 1990). Fall chinook salmon were also historically present throughout the lower parts of the Grande Ronde River subbasin, although information regarding run size is very limited. The populations of summer steelhead trout, spring chinook salmon, and fall chinook salmon have declined substantially in recent years. All coho salmon in the Columbia River drainage above Bonneville Dam are presently considered to be extinct (Nehlsen et al. 1991). Resident fish presently found in the Grande Ronde River subbasin, including the Lostine River study area, include rainbow trout and bull trout. Other native fish present in the Lostine River include mountain whitefish (*Prosopiurn williamsoni*) and sculpin (*Cottus spp.*). Introduced fish species in this system include brook trout (*Salvelinus fontinalis*).

1.1.1 Spring Chinook Salmon

Spring chinook salmon are widely distributed throughout the Grande Ronde River subbasin (ODFW 1990). The Lostine River is one of 21 streams which historically supported spawning spring chinook salmon in this subbasin, and was among its most productive spring chinook streams (ODFW 1990). Spring chinook salmon are present in tributaries located throughout the Grande Ronde River subbasin, including the Wenaha River, Wallowa River, Minam River, Lostine River, Lookingglass Creek, Catherine Creek, and Prairie Creek (Kostow 1995). These streams presently account for most of the spring chinook salmon production in the subbasin.

The Grande Ronde River subbasin historically possessed large runs of native spring chinook salmon prior to construction of dams on the lower Snake River (ODFW 1990). The estimates for

spring chinook salmon escapement into the Grande Ronde River subbasin prior to the construction of the four lower Snake River dams was 12,200 fish (ODFW 1990); the run declined to an estimated escapement of 8,400 fish in the early 1970s (Smith 1975). Spawning ground surveys conducted by ODFW indicate that the run size of this fish has declined further in recent years, with the decline primarily attributed to passage problems at Columbia and Snake River dams (ODFW 1990). Degradation of riparian and instream habitat are also partially responsible for the decline of spring chinook salmon in the Grande Ronde River. Habitat degradation has resulted from livestock overgrazing, low stream flows, logging, road construction, and entrainment into unscreened diversion ditches (James 1984; ODFW 1990). As noted above, spring chinook salmon in the lower reaches of the Lostine River have been impacted by loss of spawning and juvenile rearing habitat due to channelization, by irrigation withdrawals occurring during normal low flow periods during the later summer and fall, and by elevated water temperatures resulting from low flow conditions (Kostow 1995).

Adult spring chinook salmon migrate up the Columbia River to the Grande Ronde River subbasin in April and May (Figure 1-2). Peak immigration of adults into lower Grande Ronde River tributaries occurs in June and July (ODFW 1990). The holding period for this fish extends from May through August, with spawning occurring during the months of August and September (Figure 1-2). Grande Ronde spawners are generally three to five years in age, with the Lostine, Minam, and Wenaha rivers having the highest percentage of five year old fish observed in the subbasin. Following the spawning period, incubation of eggs and alevins extends through February, with emergence occurring primarily from January through April. Age 0+ spring chinook salmon will emigrate out of smaller tributary streams and into larger streams and rivers from August through October. These fish typically smolt at age 1+, and emigrate to the ocean from April through June (Figure 1-2).

Spawning ground surveys conducted in index areas of the Lostine River indicate that the highest concentration of spawning occurs between river miles (RM) 8.8 and 12.4 (Reach 3; Figure 1-1); (pers. comm., Brad Smith and Bill Knox, ODFW). This low gradient, meandering reach of the Lostine River contains the highest accumulation of spawning gravels in the lower river system (i.e., mouth to six mile bridge) based upon Oregon Department of Fish and Wildlife (ODFW) habitat surveys conducted in 1991. This spawning area is located above the irrigation diversions, and is consequently not impacted by flow reductions. Concentrations of spawning gravels are also

located in the lower 7 miles of the river, as well in upper sections of the river between RM 17.5 and 22.5 (Thompson and Haas 1960).

1.1.2 Early Fall Chinook Salmon

Early fall chinook salmon were present in the subbasin at the turn of the century (Bryson 1987), and a remnant of this stock was reported to be present in the lower Lostine River during coho spawning surveys conducted in 1960 (Thompson and Haas 1960). It is uncertain whether this stock is still present in the Lostine River, since no stock-specific spawning surveys are presently being conducted; these fish likely spawned from mid-september to mid-October. This early fall chinook stock was also thought to spawn in the mainstem Wallowa and Grande Ronde rivers (Thompson and Haas 1960). No other information on the life history characteristics of fall chinook salmon in the Grande Ronde River subbasin is available (ODFW 1990). However, these fish have a life history strategy similar to fall chinook salmon in the mid-Columbia River tributaries (e.g., Wenatchee River); most spawning and juvenile rearing would be expected to occur in the mainstem Grande Ronde River and into lower sections of tributaries. Most juveniles would be expected to emigrate as 0+ fish during the spring. There are no historical estimates of escapement for fall chinook salmon to this subbasin (Bryson 1987).

At the present, only a few late fall chinook salmon spawn in the lower Grande Ronde River subbasin (ODFW 1990). Fall-run chinook salmon in the Snake River basin were listed as a federal threatened species under the Endangered Species Act (ESA) in 1992 by the National Marine Fisheries Service (NMFS). The low spawning escapement of fall chinook salmon has been attributed to harvest in the Columbia River, passage mortality at Columbia and Snake river dams, and habitat degradation within the basin (ODFW 1990). Populations of fall chinook salmon in the lower Snake River rapidly declined following construction of four dams in the lower Snake River: Ice Harbor (1961), Lower Monumental (1969), Little Goose (1970), and Lower Granite (1975). The final precipitous decline in fall chinook populations occurred between 1968 and 1975.

1.1.3 Coho Salmon

The Grande Ronde River was historically the major production area for coho salmon in the Snake River basin (ODFW 1990), although the populations of coho declined rapidly following construction of the four lower Snake River dams. Declines in coho salmon were documented in

the 1960s by counts of migrating adults at the lower Snake River dams, and by spawning ground counts at index areas located in the Wallowa River drainage. There was a precipitous decline in numbers of returning adults and populations of juvenile coho salmon in this basin between 1978 to 1980. This decline coincided with the severe 1977 drought, which likely increased the impacts of the Columbia and Snake river dams on downmigrating smolts and upmigrating adults, in addition to providing poor conditions for rearing juveniles in streams, Few spawning coho salmon were counted in the Wallowa River basin after 1969 (Cramer 1990). Counts of adult coho salmon at the lower Snake River dams declined to zero by 1987; this fish species is currently considered to be extinct in the Snake River basin.

The historical distribution of coho salmon in the Grande Ronde River subbasin included the lower Grand Ronde River, the Wenaha and Wallowa river drainages, and Catherine Creek. Spawning surveys conducted in 1957 documented coho salmon spawning in the lower 5 miles (Reach 1) of the Lostine River. Adult coho salmon historically immigrated into the Grande Ronde River subbasin during September and October, and spawned during November and December (Figure 1-2). Coho salmon emerged as fry in late March and early April, and migrated out of the subbasin into the Columbia River during March through May of the following year as age 1+ juveniles. Outmigration of pre-smolts was documented during October in the lower Grande Ronde River.

The extinction of coho salmon in the Snake River, including the Grande Ronde River subbasin, can be mainly attributed to overharvest and passage problems at mainstem dams. However, a number of other factors also impacted coho salmon in this drainage. Among these, habitat degradation and severely reduced streamflows due to agricultural water diversions are evident in many of spawning and rearing areas historically used by this species (ODFW 1990). Habitat degradation and reduced streamflows could potentially constrain the reestablishment of this species into the Grande Ronde River subbasin, especially in highly impacted areas such as the lower Lostine River (Cramer 1990). Some of the most important spawning areas in the Wallowa and Lostine rivers have been degraded by channelization, flow diversions, and nutrient loading associated with agricultural development in the Wallowa River valley (Cramer 1990).

1.1.4 Steelhead Trout

The Grande Ronde River subbasin historically produced large numbers of summer steelhead trout (ODFW 1990). Historic run numbers at the mouth of the Grande Ronde River prior to

construction of the lower Snake River dams were estimated to average 16,000 adults annually. Spawning ground counts conducted in the Grande Ronde River and tributaries indicate that the number of returning adult steelhead trout declined substantially during the 1970s and early 1980s. This decline has been attributed to passage mortality at the Columbia and lower Snake River dams, and to habitat degradation. Upstream passage of adult fish and downstream passage of smolts was hindered by the construction of four dams on the lower Snake River between 1961 and 1975, and by the construction of John Day Dam on the Columbia River during this same period. The most important habitat factors limiting summer steelhead production in the Grande Ronde River subbasin are degraded riparian habitat, reductions in quality rearing habitat due to sedimentation, and reduced flows (ODFW 1990).

Adult steelhead trout typically spend between one and three years in the ocean before migrating up the Columbia River during July through August. These fish immigrate and hold in the Snake River and lower Grande Ronde River from September through April (Figure 1-2). Entrance timing into tributaries of the Grande Ronde River may occur from fall through spring, depending upon streamflow (ODFW 1990). The peak movement of adult fish into tributaries occurs around May, with spawning occurring from April through June (Figure 1-2); peak spawning from late April through the end of May. Principal spawning areas in this subbasin include middle and upper mainstream tributaries, Joseph Creek, the Wenaha River, Wallowa River, Minam River, Deer Creek, Bear Creek, and the Lostine River. Steelhead spawn in the most accessible tributaries in the lower, middle, and upper Grande Ronde River subbasin. Most spawning of summer steelhead in the Lostine River is thought to occur in the upper mainstem of the river (Reach 4 to headwaters), and in larger tributaries of upper mainstem sections (pers. comm., Brad Smith and Bill Knox, ODFW). The distribution of spawning steelhead in the Lostine River is hard to determine due to high flows and turbid conditions present during the spring period. Incubation of eggs and embryos occurs from April through July, and emergence of fry occurs from June through August (Figure 1-2). Most juvenile steelhead rear in tributary and mainstem areas of the Grande Ronde River for two to three years. Smolt migration occurs between March and May (Figure 1-2).

Steelhead trout populations in the Snake River basin were recently evaluated in a status review conducted by NMFS. This status review concluded that the steelhead trout ESU present in this basin is not presently in danger of extinction, but is likely to become endangered in the foreseeable future (Busby et al. 1996). For this reason, NMFS determined that listing of this species as a

Threatened and Endangered (T&E) Species was warranted in August 1996. While the total run size of Snake River basin steelhead has increased since the mid-1970s, this increase is largely a result of the increased production of hatchery fish. There has been a severe decline in natural steelhead stocks in the Snake River basin in recent years (Busby et al. 1996). Parr densities in this basin were found to be substantially below estimated carrying capacity in recent years. The downward trends in returning native adult fish and low parr densities indicate a particularly severe problem to steelhead in the Grande Ronde River subbasin. Genetic introgression of native fish with hatchery stocks is also a concern in the Snake River basin.

1.1.5 Rainbow Trout

Native rainbow trout are found throughout the Grande Ronde River subbasin (Kostow 1995). Rainbow trout in this subbasin include anadromous summer steelhead (described in Section 1.1.4), and resident and fluvial redband trout. Rainbow trout are considered by ODFW to be in the same conservation group as fish found in lower Snake and Imnaha rivers based upon genetic similarities (Kostow 1995). This group is considered to be reproductively isolated from Columbia River populations in Oregon. Habitat degradation is considered to be the major limiting factor to resident rainbow trout, as well as juvenile steelhead, in the Grande Ronde River subbasin (Kostow 1995). Habitat degradation in this subbasin can be attributed to channelization, grazing, timber harvest, and agricultural practices. The numerous irrigation withdrawals in this subbasin can result in severely reduced flows. Both permanent and seasonal irrigation diversion structures can inhibit or prevent the migration of fish in affected stream and river sections. Water quality impacts to rainbow trout populations include elevated temperatures, sedimentation, and organic pollution. Resident rainbow trout are found throughout the Lostine River, and occur sympatrically with summer steelhead trout.

1.1.6 Bull Trout

Both resident and fluvial forms of bull trout are found in the Lostine River, as well as other tributaries of the Wallowa River (Kostow 1995). Fluvial populations of this species probably migrate from the Wallowa River into the Lostine River. Bull trout in the lower Grande Ronde and upper Imnaha basins are thought to represent the healthiest stream-reared complex of populations in Oregon (Kostow 1995). However, results of stream surveys conducted in 1992 indicated a low abundance of adult bull trout in the Lostine River (Kostow 1995). Competition and hybridization

with brook trout represents a serious threat to bull trout populations in the Lostine River, as well as the Wallowa River and tributaries including Bear and Hurricane creeks. Juvenile and adult bull trout require cold water and clean substrates in streams (Goetz 1989). The majority of bull trout in the Lostine River are likely found in upper and headwater reaches, which are located in a U.S. Forest Service (USFS) Wilderness Area and are characterized by cold waters and clean substrates. The population in the lower river is likely to be seriously impacted by low flow conditions caused by irrigation withdrawals and elevated water temperatures directly attributed to these low flow conditions. The degraded water quality conditions found in the lower Lostine River, including elevated water temperatures and sediment problems, are not conducive to supporting healthy bull trout populations. Furthermore, channelization in the lower Lostine River substantially degrades the habitat of bull trout in these reaches.

Bull trout have been nominated for inclusion on the Federal Threatened and Endangered Species List. The listing of this species was found to be "warranted, but precluded" by the U.S. Fish and Wildlife Service (USFWS) on June 10, 1994. On May 31, 1995, the USFWS elevated the listing ranking for bull trout from 9 to 3; a lower priority number means a higher priority for listing. Bull trout in the Columbia and Klamath river basins were proposed for listing as a threatened species by the USFWS on June 13, 1997 (Federal Register Vol. 62, No. 114: 32268-32284) and was formally listed on June 10, 1998 (Federal Register Vol. 63, No. 111: 31647-31674).

1.2 HYDROLOGY

The headwaters of the Lostine River are located in the Eagle Cap Wilderness Area of the Wallowa-Whitman National Forest. Due to the high elevations and steep topography in the headwaters, the hydrology of the Lostine River is largely dependent upon seasonal patterns of snowfall and snowmelt. The yearly hydrograph of this river exhibits relatively uniform flows from September through December, with median flows during this period ranging from 40 to 47 cfs (Figure 1-4) at U.S. Geological Survey (USGS) Gaging Station 1330000 (1926 to 1991 period of record), which is located near the base of the Wallowa Mountains at RM 10. The lowest flows during this period (90 percent exceedance) range from 23 to 26 cfs from September through December, while the highest flows (10 percent exceedance) range from 81 to 115 cfs (Figure 1-4) (note: "exceedance" refers to the amount of time in which a given flow is equaled or exceeded). The stable nature of flows during this period of the year is likely due to groundwater from the deep glacial and fluvial materials underlying the Lostine River at the base of the Wallowa

Mountains. Flows in the river rapidly increase following seasonal warming and subsequent snowmelt in April and May, with peak annual runoff occurring during June (Figure 1-4). Median flows increase from 114 cfs in April to 1,260 cfs in June. The lowest flows (90 percent exceedance) during the spring range from 48 cfs in April to 376 cfs in June. The highest flows (10 percent exceedance) range from 350 cfs in April to 1,260 cfs in June. Following the peak snowmelt season in June, flows in the Lostine River rapidly drop from July through September. Median flows in the river decline from 297 cfs in July to 68 cfs in August, and then decline further to baseflow levels of 44 cfs in September (Figure 1-4). Ninety percent exceedance flows during July and August are 94 and 27 cfs, respectively. The 10 percent exceedance flow for July is 770 cfs, and for August 152 cfs.

Flows in the upper Lostine River drainage are partially affected by irrigation diversions from Minam Lake, which is located in the headwater of the river drainage. Minam Lake has a storage capacity of 440 acre-ft, and has stored and diverted flow from the Minam River since 1917 into the Lostine River drainage. The impact of water storage and diversions at Minam Lake on the lower Lostine River is minor, since the stored water is used up in a couple of weeks.

Flows in the lower Lostine River, unlike the upper river, are impacted by a number of agricultural water diversions. Most of these diversions are located immediately south and northwest of Lostine, Oregon (Figure 1-1). The largest diversion between the Wallowa River confluence and Lostine is the Clearwater Ditch (RM 2.9). Smaller diversions in this reach include the Tulley Hill, Foster, Fitzpatrick, and Miles ditches. The Cross Country Ditch (Figure 1-1; RM 5.5) is a major agricultural return located just north of Lostine; diverting water from the Wallowa River into the Lostine River. The water diverted into the Lostine River from the Wallowa River is subsequently diverted into the Clearwater Ditch, which is located 2.5 mi downstream of the Cross Country Ditch. Major diversions south of the City of Lostine include the Poley-Allen Ditch (RM 6.8), the Lostine Ditch (RM 7.0), the Sheep Ridge Ditch (RM 8.3), and the Westside Ditch (RM 8.8). The Westside Ditch is the most upstream irrigation diversion which reduces flows in the Lostine River. The only diversion upstream of the Westside Ditch is the Krieger Pond (Strathearn) Diversion (RM 11.3). However, flows at this point are only used to maintain water levels in recreational pond, and are returned to the Lostine River a short distance downstream.

These diversions reduce flows in the Lostine River during the irrigation season, which generally extends from May 1st through September 30th. The dominant irrigated crops in the Wallowa

Valley are hay and wheat. Flows in the river typically return to natural levels from late September to mid-October fallowing completion of the irrigation season. Irrigation diversions can substantially reduce flows in the lower reaches of the Lostine River below those observed at USGS Gage 13130000.

The impacts of these diversions on river flows are evident from discharge records obtained from two gaging stations initially established in lower reaches of the river by the USGS during 1995 (Figure 1-5). The lowermost gage is located downstream of the Clearwater Diversion at RM 1.1 (Reach 1), while the upstream gage is located at Lostine (RM 5.5) just upstream of the Cross Country Ditch (Reach 2). During August through September 1995, flows at the uppermost USGS gaging station (Reach 3; located above the irrigation diversions) ranged from 47 to 190 cfs. At the USGS gage located at Lostine (Reach 2), flows during this period ranged from 11 to 120 cfs. At the lowest USGS gage located downstream of the Clearwater Ditch (Reach 1), flows ranged between 7 and 55 cfs during this period. Flows were similar at all three gages from November 1995 through July 1996, reflecting that the irrigation ditches were not in operation.

Reductions in flows due to irrigation diversions are also evident from hydrology data obtained at these three gages from August through October 1996 (Figure 1-5). While discharge values ranged from 38 to 262 cfs at the uppermost gage located above the diversion, flows ranged from 12 to 192 cfs at the gaging station located at Lostine, and from 10 to 240 cfs at the gaging station located below the Clearwater Diversion. Both 1995 and 1996 were considered wet years due to high snowfall accumulations in the Wallowa Mountains. Reductions in flow in the lower Lostine River can be more severe during dry years; discharge values above the diversions have ranged from 20 to 30 cfs during September (USGS gaging records, 1926-1991). Under such climatic conditions, flows in the lower Lostine River likely drop below 5 cfs due to irrigation diversions.

1.3 INSTREAM FLOW ISSUES

The impacts of reduced flows on anadromous and resident fish species in the lower reaches of the Lostine River are a major concern to agency and tribal biologists who manage fish resources in this drainage. These concerns are primarily centered on the lower reaches of the river adjacent to and west of Lostine (Figure 1-1), which are subjected to flow reductions caused by agricultural water withdrawals during the July through September irrigation season. Flows throughout the entire Lostine River are marginally affected by flow releases from Minam Lake. Some of the

water released from this lake is diverted from the Minam River; this water is subsequently used for the irrigation of agricultural lands located within the Lostine River drainage. Flow reductions in the lower 8.7 mi of the Lostine River can be severe due to numerous irrigation diversions located within this section of the river.

Reduced flows in the lower Lostine River can adversely impact anadromous and resident fish species in a number of ways. Low flows create passage barriers for migrating spring chinook salmon and fluvial populations of bull trout, and likely created passage barriers for early fall chinook salmon and coho salmon on a historical basis. Reductions in flow can result in poor quality holding habitat in many sections of the lower river where spring chinook salmon, early fall chinook salmon, and coho salmon have been historically present. These flow reductions can also adversely impact the spawning and incubating habitat of spring chinook salmon and bull trout, and historically impacted the spawning and incubation of coho salmon and early fall chinook salmon. Finally, reductions in flow can severely degrade the rearing habitat of juvenile steelhead trout, spring chinook salmon, and historically coho salmon, as well as juvenile rearing and adult habitat of rainbow trout and bull trout. The lower reaches of most tributaries to the Wallowa River, including the Lostine River, have been impacted by extremely low flows caused the diversion of water for irrigation.

Minimum streamflows for the Lostine River were established by the ODFW on November 3, 1983, under the provisions of Oregon's "minimum streamflow" law of 1955. These minimum flows apply to the section of Lostine River from the USGS gage located at RM 9.9 to the confluence of the Wallowa River, and are provided as follows:

October – 50 cfs
November – 60 cfs
December through April – 40 cfs
May through mid-June – 60 cfs
Mid-June through mid-August – 50 cfs
Mid-August through September – 70 cfs

The minimum streamflows established by ODFW for the Lostine River were based upon the "Oregon" instream flow methodology (Smith 1975) as part of a water resources planning effort in the Grande Ronde River subbasin. This method considers both upstream passage and channel

geometry (e.g., wetted perimeter) in determining minimum instream flows. The flows recommended by this study were not based upon the habitat requirements (e.g., velocity, depth, and substrate) of the anadromous and resident fish species and life stages present in the Lostine River. Consequently, relationships between flow and habitat quantity and quality could not be developed using this method. Moreover, the flows recommended by this method frequently exceeded the natural daily flows present in the Lostine River from August through October (as measured at USGS Gage 13330000), which is the period when flows are probably most limiting to fish. For these reasons, the flow recommendations based upon the "Oregon" method could not be used to determine the minimum flows required to improve fish habitat and populations in the Lostine River.

Under revisions to Oregon's water law in 1988, these minimum instream flows are legal water rights allocated for instream flow with the priority date set as that date when the flows were originally established (i.e., November 3, 1983, for the Lostine River) (ODFW 1990). However, the majority of water rights for the Lostine River are senior to the priority date established by ODFW for minimum streamflows. Because most streams in the Grande Ronde subbasin, including the Lostine River, have over-appropriated water rights, these minimum flows provide little or no benefit to fish during critically low flow conditions. However, water can be sold, leased or donated by private water rights holders to ODFW under Oregon water law for providing minimum instream flows and other beneficial instream uses.

1.4 STUDY OBJECTIVES

Fisheries biologists with the Nez Perce Tribe (NPT) and ODFW, in coordination with the Bureau of Reclamation (BOR) and the Bonneville Power Administration (BPA), identified the need to conduct an instream flow study in the Lostine River during meetings held in 1995. The NPT and agencies decided to implement an instream flow study using the Instream Flow Incremental Method (IFIM), a set of analytical procedures and computer simulation models developed and supported by the USGS Midcontinent Ecological Science Center (MESC; formerly the USFWS's Instream Flow Group). This study was recommended by the NPT, ODFW, BOR, and BPA due to the historical and present importance of the anadromous and resident fish resources in the Lostine River, and because of the adverse impact of irrigation withdrawals during low flow periods on these resources. Prior instream flow assessments of the Lostine River using the "Oregon" method were not considered to be detailed enough to determine minimum flow requirements for all of the species and life stages of anadromous and resident fish currently or historically present in this river.

Based upon these recommendations, the NPT contracted with R2 Resource Consultants (R2) to conduct an instream flow study for the lower Lostine River using IFIM. This study was funded by the BOR and BPA, with the NPT designated as the lead agency in charge of the project. After conducting a reconnaissance trip to the Lostine River, and meeting with ODFW and the NPT in Enterprise, Oregon, a scope of work was developed for this study. This scope of work was approved by ODFW and the NPT, and the study subsequently initiated during September 1995. The study had several objectives, including:

- Develop a segmentation rationale based upon channel, hydrological, and habitat characteristics to divide the Lostine River into study reaches;
- Establish study sites which are representative of "typical" and "critical" fish habitat in each reach;
- Establish transects within each study site from which hydraulic and channel characteristics will be measured at different flows;
- Develop a calibrated hydraulic simulation model for each site, which will be used for simulating habitat conditions (including depth, velocity, substrate type, and cover) over a wide range of flows;
- Develop habitat suitability index (HSI) criteria for target species and life stages of fish which are applicable to habitat conditions observed in the Lostine River;
- Develop habitat versus flow relationships for each target species and life stage using MESC's "Physical Habitat Simulation System" (PHABSIM) in each study reach of the Lostine River;
- Identify the minimum flows needed to provide successful upstream passage of adult anadromous fish and migrating resident fish (e.g., fluvial bull trout); and
- Evaluate potential impacts of reduced flows on these target species and life stages.

The results of the study (habitat versus discharge relationships) would be used to identify recommended minimum flow regimes for the Lostine River which could be used to protect anadromous and resident fish species.

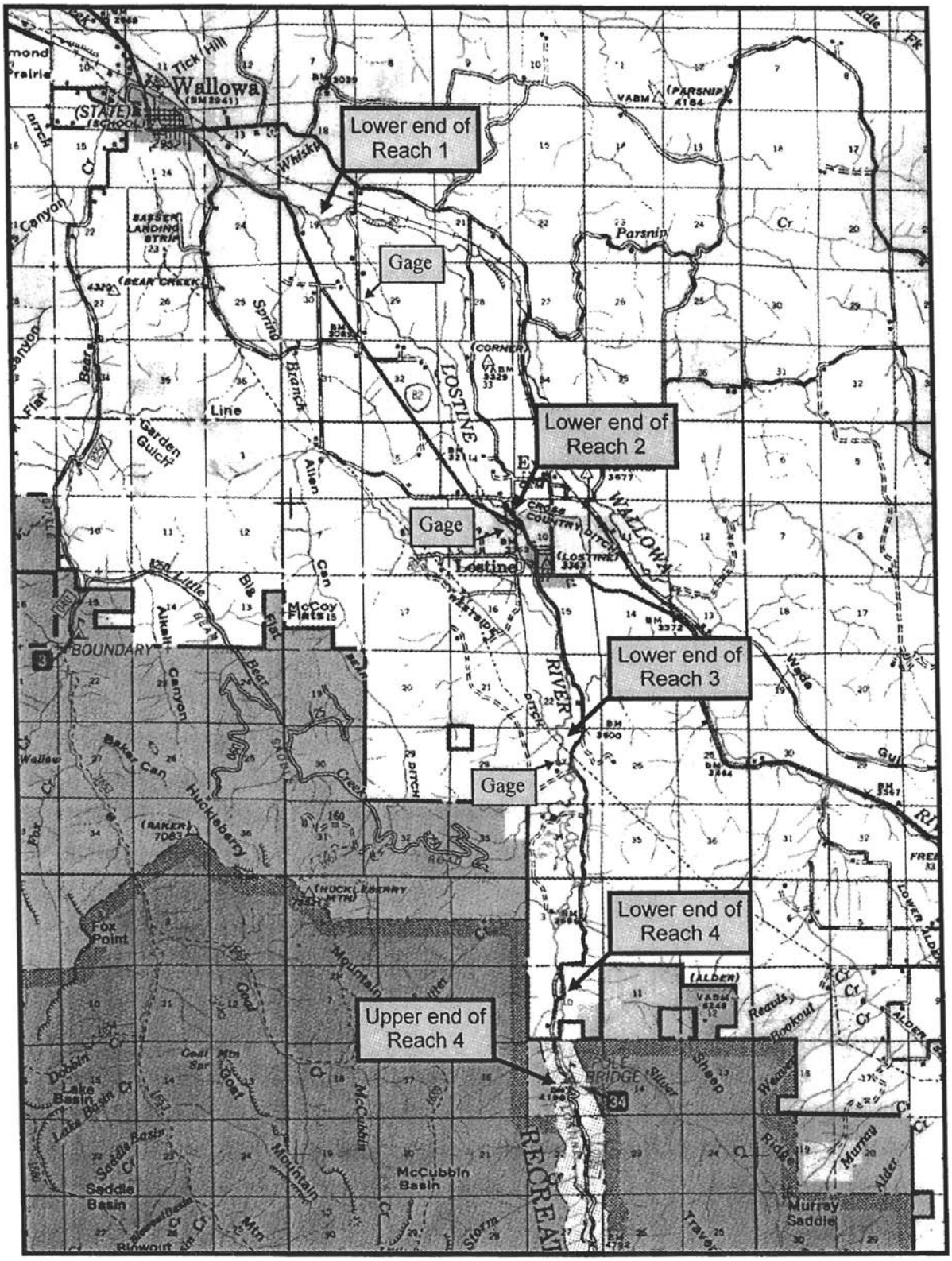

Figure 1-1. Map of the Lostine River study area (Wallowa County, Oregon) showing location of PHABSIM study reaches and stream gaging stations.

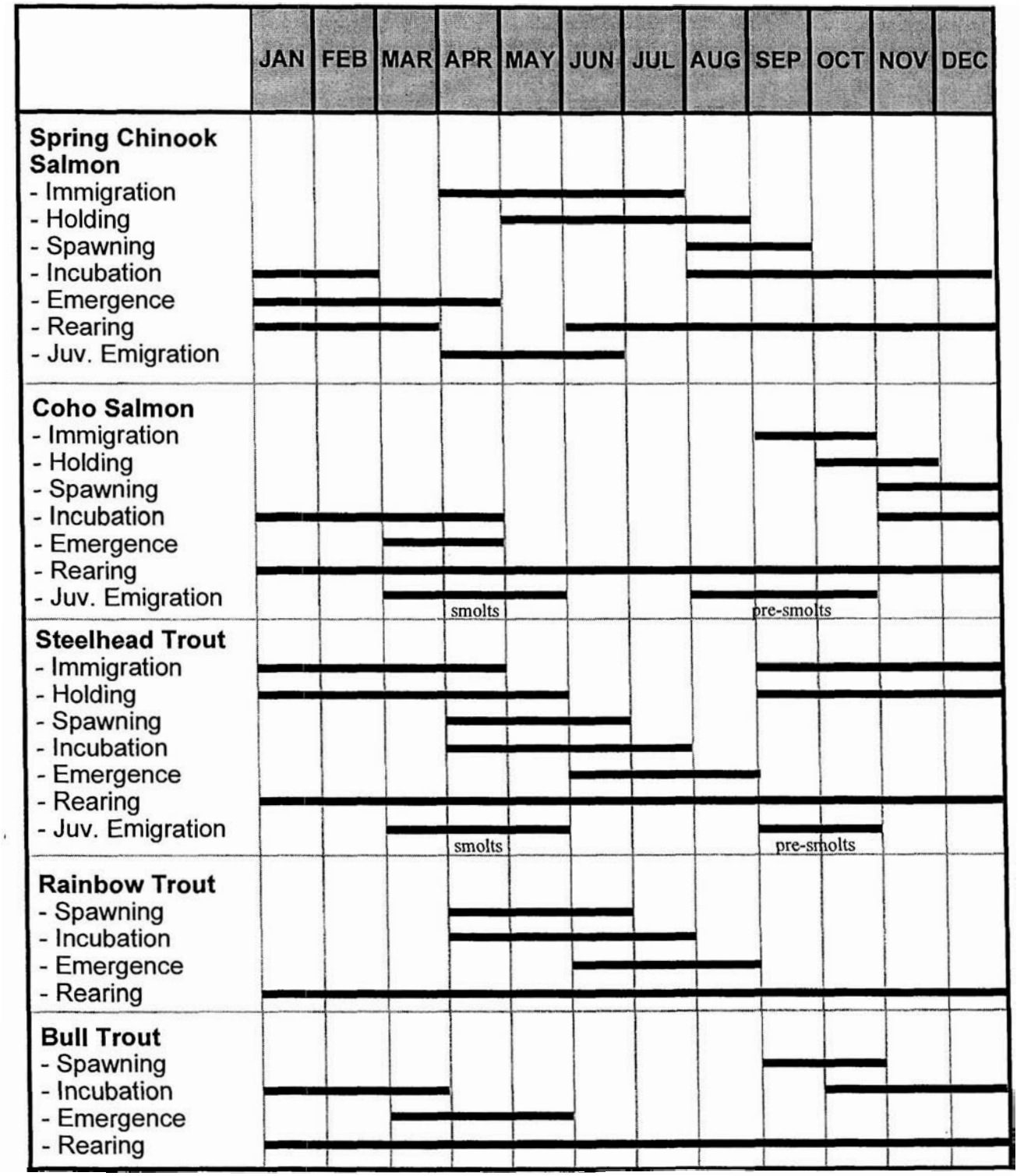

Figure 1-2. Life stage periodicity for target anadromous and resident fish species in the Grande Ronde River subbasin. Coho salmon are presently extinct in the Snake River drainage, including the Grande Ronde River subbasin (source: ODFW 1990).

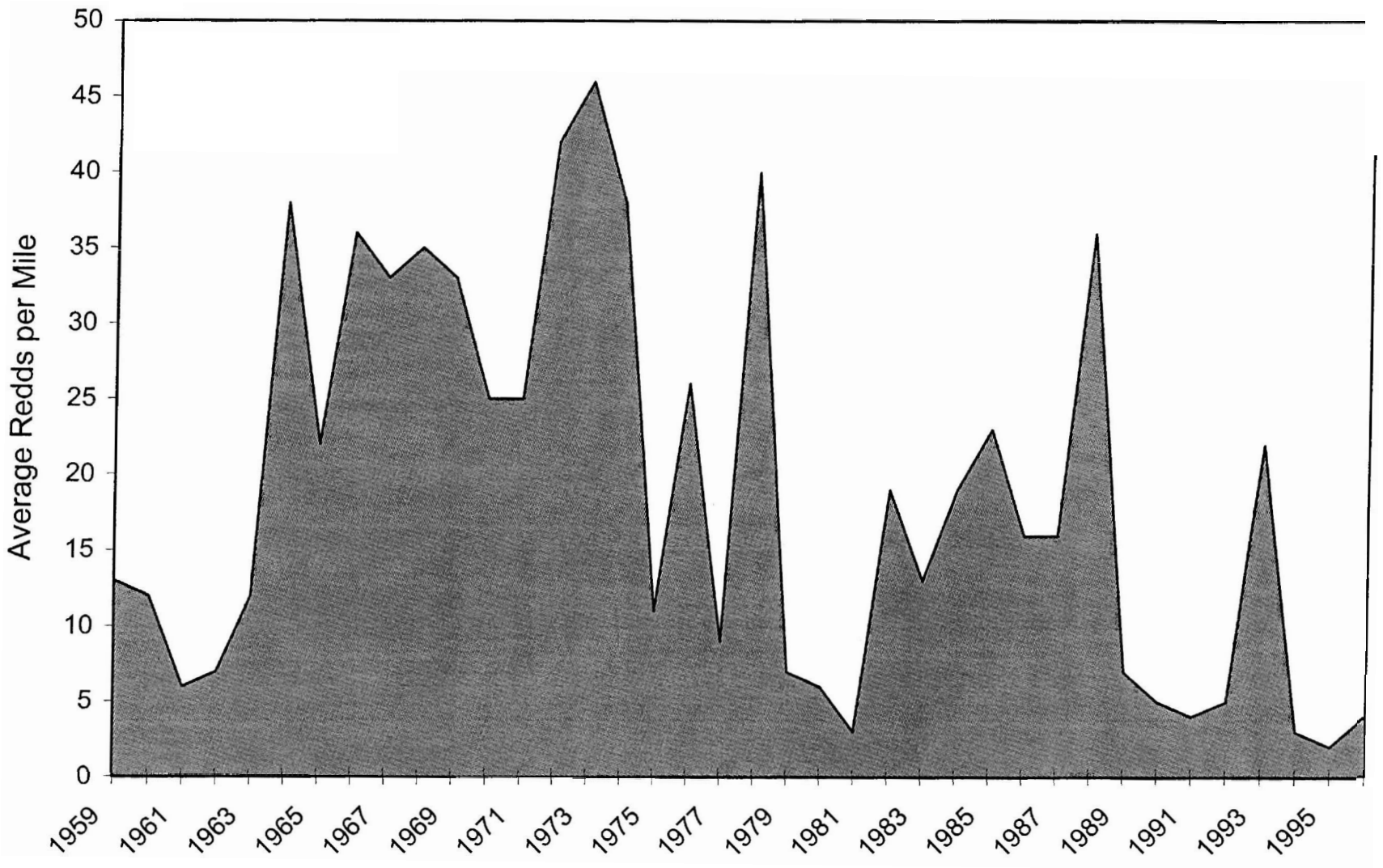

Figure 1-3. Average count of spring chinook salmon redds per mile within index areas of the Lostine River, Oregon; 1959-1996 (source: ODFW and NPT unpublished data).

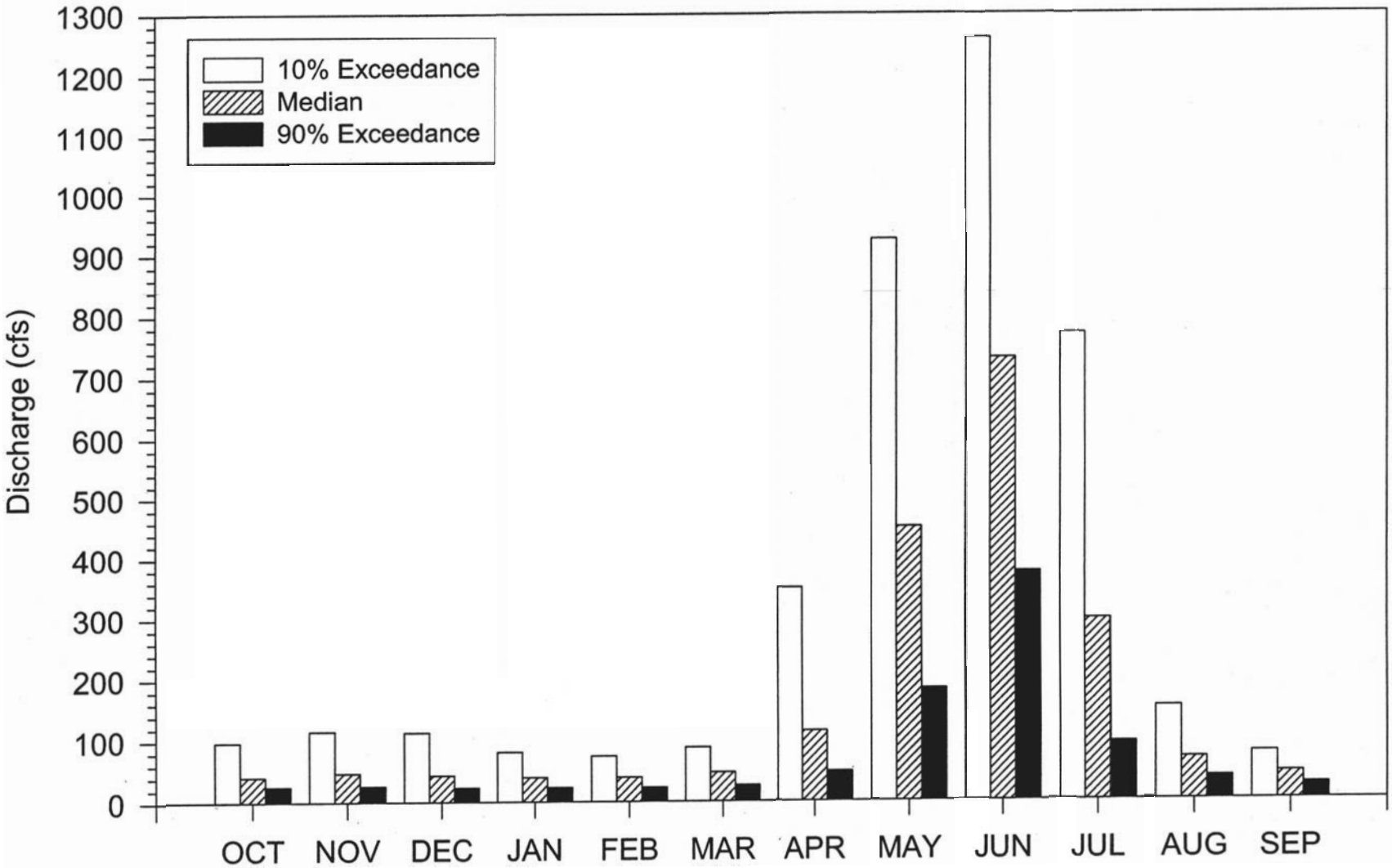

Fig 1-4. Median, 10 percent exceedance, and 90 percent exceedance flows for the Lostine River, Oregon (source: USGS Gaging Station 13330000, 1926 through 1991).

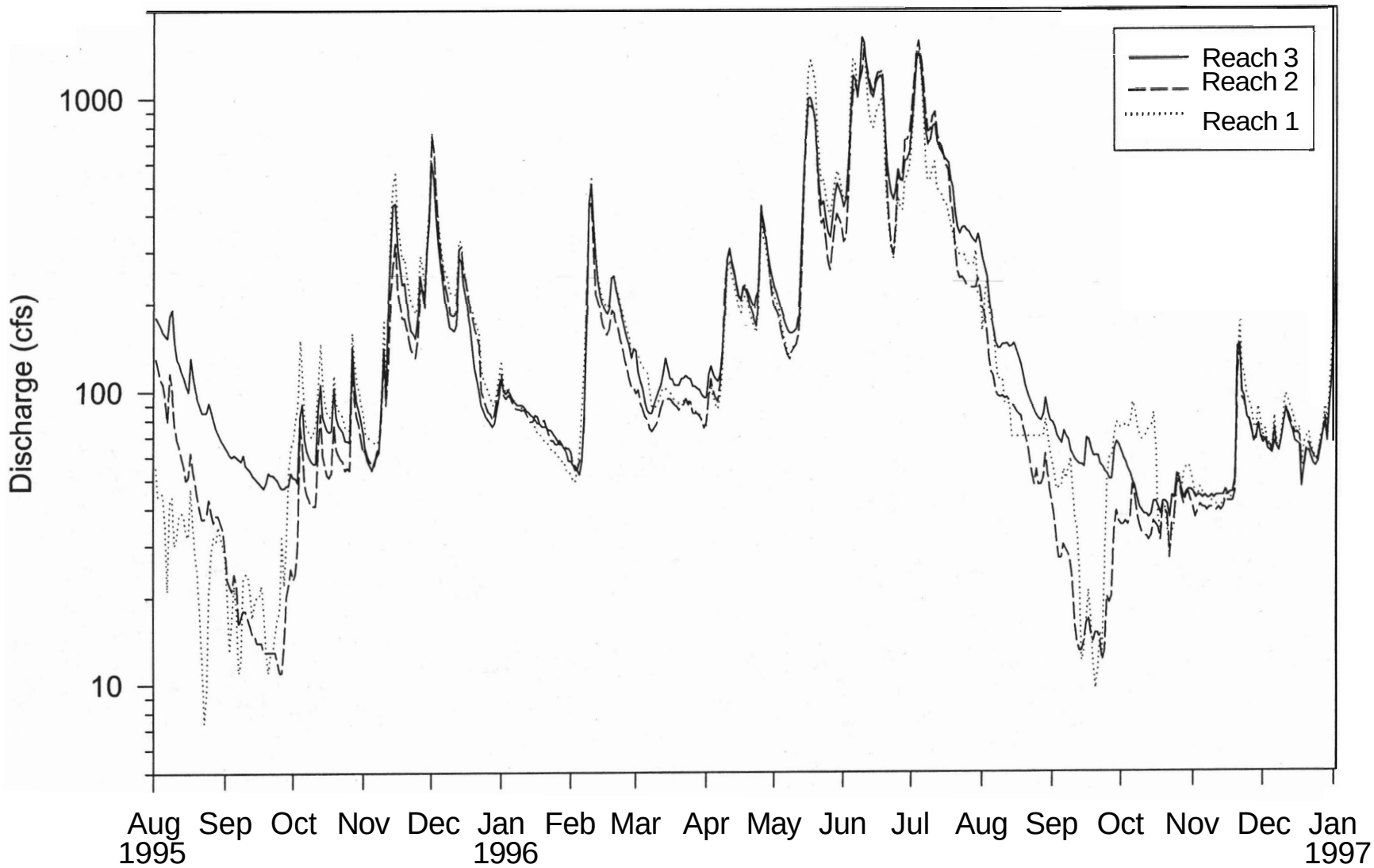

Figure 1-5. Comparison of daily discharge values for gaging stations located in Reach 1, Reach 2, and Reach 3 of the Lostine River, Oregon (sources: USGS 1997; unpublished USGS data).

2. DESCRIPTION OF STUDY AREA AND STUDY SITES

The Lostine River originates in the Eagle Cap Wilderness, which is located in the Wallowa Mountains of northeastern Oregon. The river runs in a northern direction from its origin at Minam Lake. Most of the upper river is bounded by steep topography, with elevations exceeding 10,000 ft in the headwaters of the Lostine River. The upper river flows within a steep granitic mountain canyon located within the boundaries of the Wallowa-Whitman National Forest and Eagle Cap Wilderness. This section of the river has been designated as a National Wild and Scenic River (both "wild" and "recreational" management classifications apply).

The instream flow study focused on the lower 13.9 mi of the Lostine River (Figure 1-1), which is located in forested and agricultural lands. The lower boundary of the study area is the confluence of the Lostine River with the Wallowa River, located just east of Wallowa, Oregon. The upper boundary of the instream flow study area is Pole Bridge, which is located approximately 0.6 mi south of the boundary of the Wallowa-Whitman National Forest. The lower 8.8 mi of the study area is located within the Wallowa valley, through which both the Lostine and Wallowa rivers flow. Farming (mainly hay and wheat) and cattle ranching are the dominant land uses in this broad agricultural valley. The upper 5.0 mi of the study area are located in a confined valley bottom bounded by the lower slopes of the Wallowa Mountains. This area is dominated by coniferous forest and lowland meadows, and includes lands in both private (primarily residential and recreational use) and public (National Forest) ownership.

Based upon meetings and discussions with ODFW district fisheries biologists (Brad Smith and Bill Knox) and the regional NPT fisheries biologist (Don Bryson), the Lostine River was divided into four reaches (Figure 1-1, Figure 2-1) for the instream flow study, This segmentation was based upon changes in channel structure and gradient, hydrology, and fish habitat characteristics. Instream flow study sites were then established within each of these reaches to represent the habitat conditions present in each reach. The location of these study sites was determined in collaboration with the aforementioned fisheries biologists, who are familiar with habitat conditions and fish resources in the Lostine River. The four instream flow reaches, and the instream study sites established in each reach, are described in the following sections.

2.1 REACH 1—WALLOWA RIVER TO CROSS-COUNTRY DITCH

Reach 1, the most downstream of the four instream flow study reaches, extends from the confluence of the Wallowa River (RM 0.0) to the Cross-country Ditch (RM 5.3), which is located at the town of Lostine, Oregon (Figure 2-1). Reach 1 is 5.3 mi in length and has a moderate gradient of 1.1 percent. This reach of the Lostine River flows in a northwest direction through valley-bottom agricultural lands of the Wallowa Valley (see Figure 1-1). Flows within Reach 1 are reduced by diversions located both in this reach, and by diversions located upstream in Reach 2. Reach 1 contains sections which have been channelized, as well as sections which are severely impacted by extensive bank erosion and channel braiding. Much of the historic habitat degradation in Reach 1 can be attributed to land reclamation activities, including construction of dikes and drainage canals that were used to convert the original low-lying marshlands of the Wallowa Valley into agricultural lands. Habitat in this reach is characterized by long riffles and runs composed primarily of small to large cobble-sized substrates. Cottonwoods and alders are the dominant streamside vegetation in this reach. This reach has few large pools; these are typically associated with bedrock outcroppings.

Four instream flow study sites were established in Reach 1, the most in any reach (Figure 2-1). A greater number of study sites were placed in this reach because it was substantially longer than the other reaches, because it contained both channelized and natural channel sections, and because it was the most impacted reach by irrigation diversions. The four study sites located in this reach were:

- *Site 1* - This site is located within a channelized section of Reach 1 at RM 1.2 (Figure 2-2) (western section of Wolfe Ranch). The site is characterized by long, uniform riffles and runs dominated by small to large cobble-sized substrates (i.e., 3 to 12 inches in diameter). Short, higher gradient (> 2 percent slope) riffles and rapids are present in this section; these habitat types are associated with large cobbles and riprap material. Pools in this section are scarce, and found primarily in association with large pieces of riprap that had fallen into the channel. The left bank of this site is diked, while the right bank is composed of riprap. The dominant streamside vegetation at this site is cottonwoods.

- *Site 2* - This site is located within a section of natural channel at RM 1.7 (Figure 2-3) (Johnson Ranch). Habitat within this site is characterized by long riffles and runs, and occasional deep pools associated with bedrock outcroppings. The dominant streambed substrates at this site are large gravel, small cobble, and large cobble. The left bank of this site is a low lying terrace containing exposed cobbles;

a small dike is located between this terrace and farmlands located beyond. The right bank is situated upon a steep hillslope. Dominant streamside vegetation along the left bank are cottonwoods and alders, while junipers and brush are found along the right bank.

- *Site 3* - This site is located within a section of natural channel at RM 2.1 (Figure 2-4) (Johnson Ranch). Habitat within this site is charactered by long and uniform riffles and runs, and occasional deep pools associated with bedrock outcroppings. Like the previous site, the dominant streambed substrates are large gravel, small cobble, and large cobble. The left bank of this site is a low lying terrace thickly vegetated by alders and small cottonwoods; the right bank is composed of a high, flat soil terrace vegetated by junipers, Jeffrey pine, and shrubs.

- *Site 4* - This site is located at RM 3.7 within a braided, unstable channel section possessing highly eroded and disturbed banks (Figure 2-5) (eastern section of Wolfe Ranch). Habitat within this site is charactered by broad riffles and runs; pools are infrequent and found primarily in association with root wads or large woody debris. The left bank of this site is covered with small and large-sized cobbles, which appeared to have been dredged. A number of active drainage canals and dikes are located beyond the low and disturbed cobble terrace located along the left bank. An eroded soil bank extended along the right side of the river at this site. Vegetation along the left bank is mainly young alders and cottonwoods located within loose cobbles. The right bank is vegetated by mature cottonwoods.

2.2 REACH 2--CROSS-COUNTRY DITCH TO WESTSIDE DITCH

Reach 2 extends from the Cross County Ditch (RM 5.3) to the Westside Ditch (RM 8.8) (Figure 2-1). Reach 2 is 3.5 mi in length, and has an average gradient of 1.7 percent. This reach runs in a northern direction and is located within sloping farmlands and ranches located at the foot of the Wallowa Mountains. This reach is the most impacted of the four reaches by irrigation diversions. The lower sections of this reach are extensively channelized and are characterized by long riffles and runs dominated by large cobbles. The upper sections are semi-channelized to natural, and are characterized by long riffles and runs dominated by large cobbles and small boulders. The natural channel sections in upper Reach 2 possess a considerable amount of "pocket water" habitat provided by large cobbles and boulders. These natural channel sections appear to provide good to excellent habitat for juvenile steelhead and rainbow trout, adult rainbow trout, and juvenile chinook salmon. Reach 2 progressively increases in gradient in an upstream direction, with streamside vegetation making an upstream transition from cottonwoods to conifers.

Three instream flow study sites were established in Reach 2 (Figure 2-1) as follows:

- ***Site 1*** - This site is located within a semi-channelized section at RM 5.5 (Figure 2-6) (Cameron Ranch). The site is characterized by long and uniform riffles and runs dominated by small to large cobble-sized substrates. Short sections of high gradient riffles dominated by large cobbles and boulders are also present in this section of the river. Pools in this section are scarce and found primarily in association with outcroppings of riprap or boulders along the bank. Eroded soil and live root wads extended along the left bank. The right bank is a broad cobble bar, which sloped gradually up to a dike. The dominant streamside vegetation at this site is cottonwoods.

- ***Site 2*** - This site is located within a section of the river containing both semi-channelized and natural channel at RM 7.2 (Figure 2-7) (Wynan Ranch). The site is characterized by riffles and runs dominated by large cobble-sized substrates and small boulders. Sections of "pocket water" habitat are also found within this site. Pools in this section are scarce and found primarily in association with outcroppings of riprap or boulders along the bank and at sharp bends. The left bank is steep and composed of soil, live root wads, and large boulders. The right bank is a broad cobble bar which sloped up to a wetland terrace. Dominant strearnside vegetation along the left bank includes large cottonwoods and conifers, and along the right, riparian shrubs (red ozier dogwood) and cottonwoods.

- ***Site 3*** - This site is located within a natural channel section of the river at RM 8.1 (Figure 2-8) (Cherry Ranch). The site is characterized by broad riffles and runs dominated by large cobble-sized substrates and small boulders, and higher gradient "pocket water" habitat dominated by boulders. Pools in this section are found in association with boulder outcroppings and sharp bends in the river. The left bank is steep and covered by eroded soil, live root wads, and large boulders; a high wooded terrace is located beyond this bank. The right bank is also steep, and covered by live root wads. **A** sloping meadow is located immediately beyond the right bank. Streamside vegetation is dominated by large conifers (Jeffery pine), which provided excellent shading to the river channel.

2.3 REACH 3-WESTSIDE DITCH TO HIGHWAY 551 BRIDGE

Reach 3 extended between the Westside Ditch (RM 8.8) to the Highway 551 Bridge (RM 12.4). This reach was 3.5 mi in length, and had a much lower gradient (0.7 percent) than Reaches 1 and 2. This section of the Lostine River runs in a northern direction through a narrow wooded meadow valley located at the foot of the Wallowa Mountains (see Figure 1-1). The only diversion located in the reach is the Krieger Pond ditch, which diverts water to a recreation pond. Water

from this pond is diverted back into the river a short distance downstream. The lower section of this reach is characterized by long, uniform riffles and runs, and deep pools associated with woody debris and sharp bends in the river. This reach is dominated by gravels and small cobbles; it contains the highest concentration of spawning-sized gravels in the Lostine River study area. The upper section of this reach is much broader, and contains both braided and multiple channel areas. Channel braiding and bank erosion in sections of this reach appear to have been a result of gravel mining. Banks along some of the disturbed areas have been hardened with riprap. Gabion deflectors have been installed in some of the disturbed areas to improve habitat conditions for spawning and rearing chinook salmon. This reach has the highest concentration of spring chinook salmon spawning habitat use in the Lostine River, and therefore is considered to be a "critical reach" in the context of the instream flow study.

Three instream flow study sites were established in Reach 3 (Figure 2-1), including:

- ***Site 1*** - This site is located at RM 9.1 (Figure 2-9) (northern end of Krieger Property). The undisturbed site is characterized by long and uniform riffles and runs dominated by small cobbles and gravels. Accumulations of gravels within this site are substantially lower than those found at Sites 2 and 3 within this same reach. Pools are abundant within Site 1, and are found primarily in association with woody debris and sharp bends in the river channel. The long glides and tail-out sections of pools possessed clean gravels, which provide excellent spawning areas for chinook salmon, steelhead trout, and resident trout (i.e., rainbow and bull trout). The left bank is situated at the foot of a steep hillslope and composed of soil and live root wads. The right bank is low and comprised mainly of vegetated soil. A wooded wetland is located immediately beyond the right bank. The dominant streamside vegetation at this site is mature conifers (Jeffery pine and lodgepole pine) and young alders.

- ***Site 2*** - This site is located at RM 10.4 (Figure 2-10) (middle of Krieger Property), and is characterized by long and uniform riffles and runs dominated by gravels and small cobbles. Deep pools are abundant within this site; most of these pools are associated with woody debris accumulations. The pools located within this site likely provide important holding habitat to spring chinook salmon and summer steelhead trout, as well as excellent habitat for adult rainbow trout and possibly bull trout. The gravel dominated glides and tail-out sections of pools found within this site provide excellent spawning habitat for salmon, steelhead, and resident trout. Both the left and right banks of this site are comprised of gently sloping loose gravels and cobbles. The dominant streamside vegetation at this site is young alders.

- *Site 3* - This site is located at RM 10.9 (southern end of Krieger Property). The site is characterized by broad riffles and runs which are dominated by gravels and small cobbles, and is located in a section of the river disturbed by past gravel mining activities (note: a recently closed gravel mining area is located approximately 1,500 ft south of this site). This site contained sections of braided channel which are caused by severe bank erosion probably resulting from gravel mining activities. Even though this site is disturbed, the riffle and run habitats found within are dominated by clean gravels which likely provide good spawning habitat for salmon, steelhead, and resident trout. The left bank of this site is comprised of loose gravels and cobbles. **A** gradual vegetated slope extended along the right bank. The dominant streamside vegetation at this site is young alders.

2.4 REACH 4—HIGHWAY 551 BRIDGE TO POLE BRIDGE

Reach 4 extends between the Highway 551 Bridge (RM 12.4) and Pole Bridge (RM 13.9). This 1.5-mi-long reach has a much higher gradient (4.2 percent) than downstream reaches. Reach 4 is located in a confined canyon; the steep slopes of the Wallowa Mountains bound this entire reach. The reach flows through heavily forested lands which are in both USFS and private ownership, and is characterized by boulder-dominated runs, riffles, and rapids. Water velocities are substantially higher in this reach than in lower reaches due to the steep gradient and confined nature of the river channel. Pools in this reach are generally associated with bedrock outcroppings; short "step" pools are also found within steeper canyon sections dominated by large boulders. Gravel accumulations in Reach 4 are rare due to the steep gradient of the river channel. This reach is the least disturbed of the four instream flow study reaches. No diversions are located in this reach of the river, so minimum instrearn flows are not a concern in this reach. However, this reach was studied at the request of the NPT and ODFW to better understand the habitat conditions in this undisturbed section of the Lostine River.

A single study site was established in Reach 4 (Figure 2-1; Figure 2-5) and is described as follows:

- *Site 1* - This site is located in a narrow canyon section of the Lostine River at RM 13.3. The site is characterized by high gradient riffles and cascades dominated by boulders. Pools are found primarily in association with bedrock outcroppings. The left bank was steep and composed of soil and live root wads. The right bank was a steep bedrock wall. The dominant strearnside vegetation at this site was conifers, which provided excellent shading to the river channel.

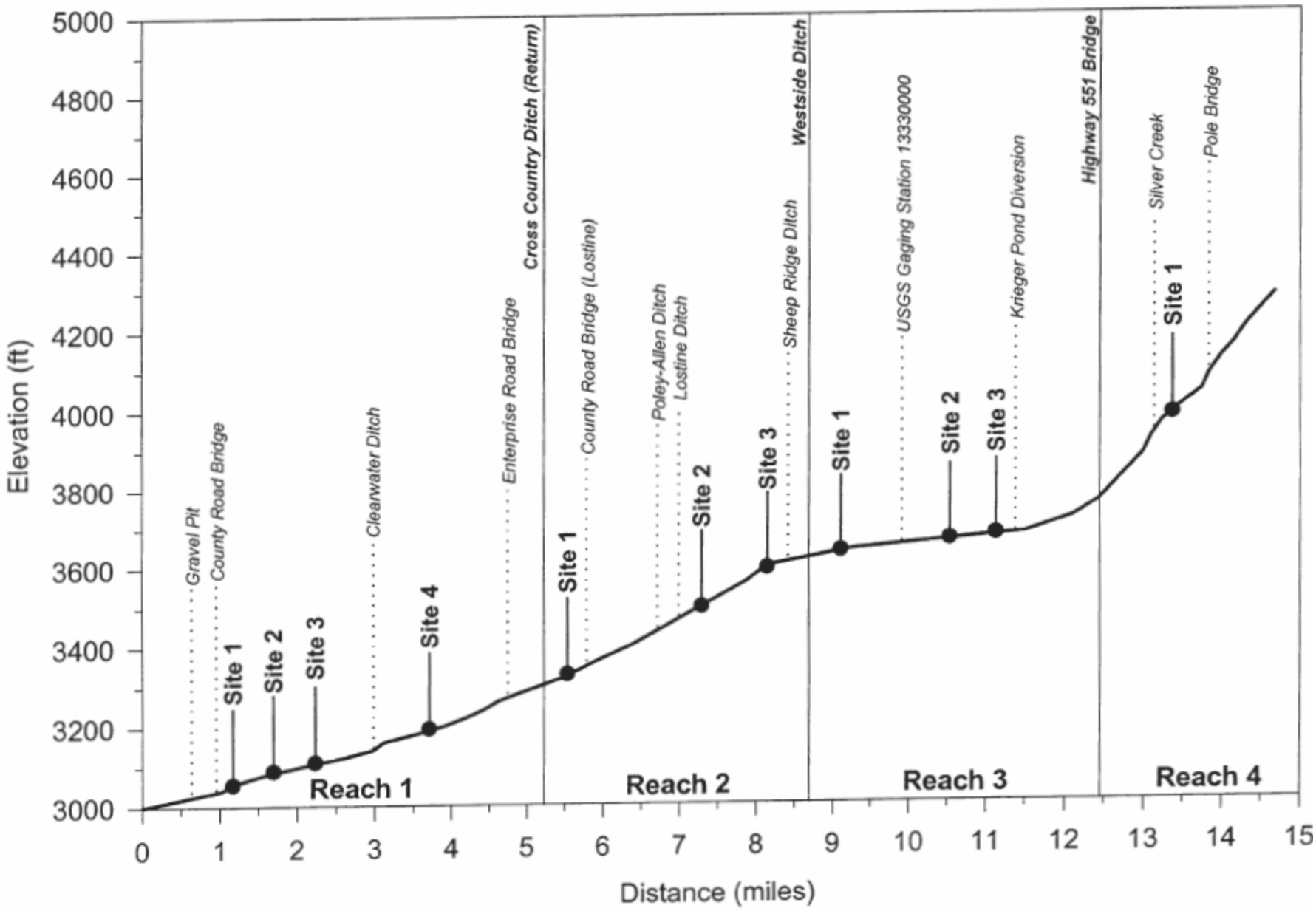

Figure 2-1. Longitudinal profile of Lostline River, Oregon study area, including study reach delineations and PHABSIM site locations.

Figure 2-2. Photograph of Reach 1, Site 1, Lostine River, Oregon. Photograph taken on August 16, 1995, during flow of 65 cfs.

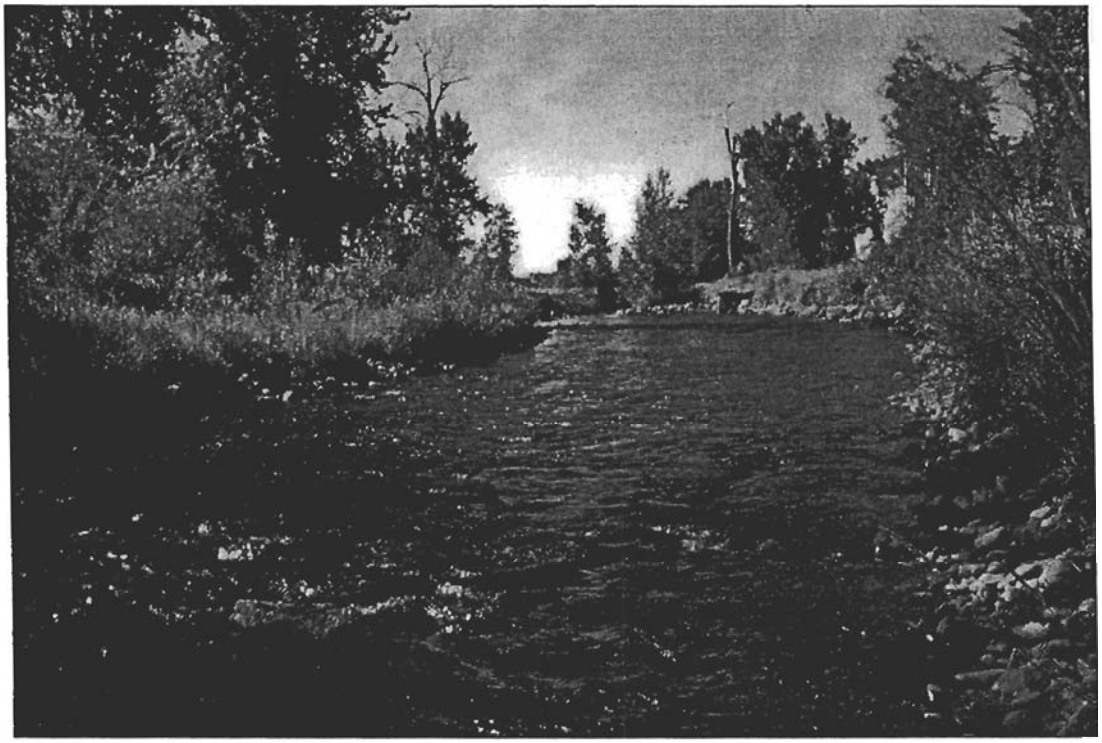

Figure 2-3. Photograph of Reach 1, Site 2, Lostine River, Oregon. Photograph taken on August 14, 1995, during flow of 46 cfs.

Figure 2-4. Photograph of Reach 1, Site 3, Lostine River, Oregon. Photograph taken on August 14, 1995, during flow of 43 cfs.

Figure 2-5. Photographs of Reach 1, Site 4, Lostine River, Oregon. Photograph taken on August 16, 1995, during flow of 61 cfs.

Figure 2-6. Photograph of Reach 2, Site 1, Lostine River, Oregon. Photograph taken on August 15, 1995, during flow of 52 cfs.

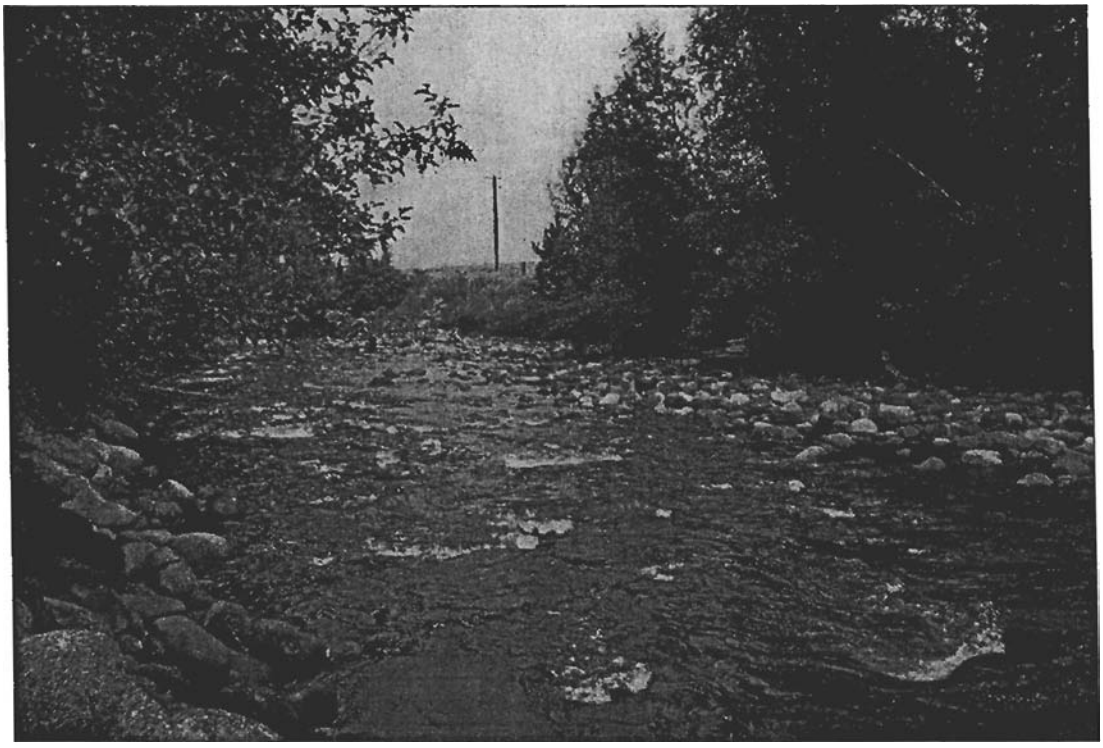

Figure 2-7. Photograph of Reach 2, Site 2, Lostine River, Oregon. Photograph taken on August 16, 1995, during flow of 64 cfs.

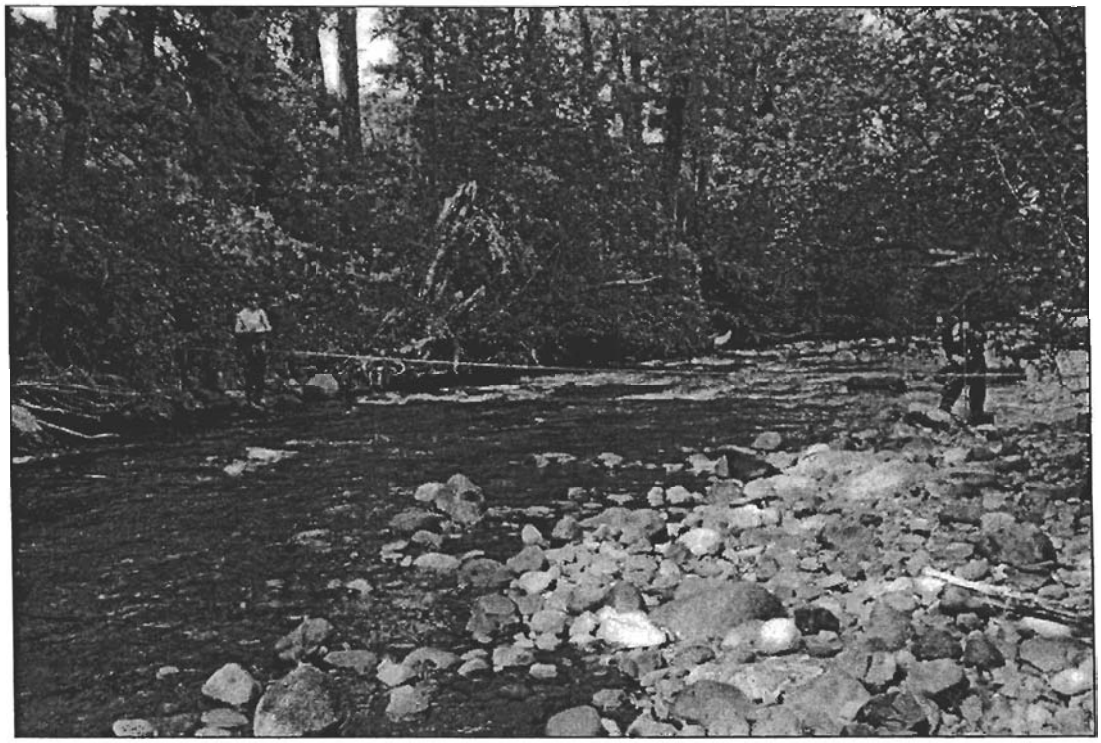

Figure 2-8. Photograph of Reach 2, Site 3, Lostine River, Oregon. Photograph taken on August 16, 1995, during flow of 67 cfs.

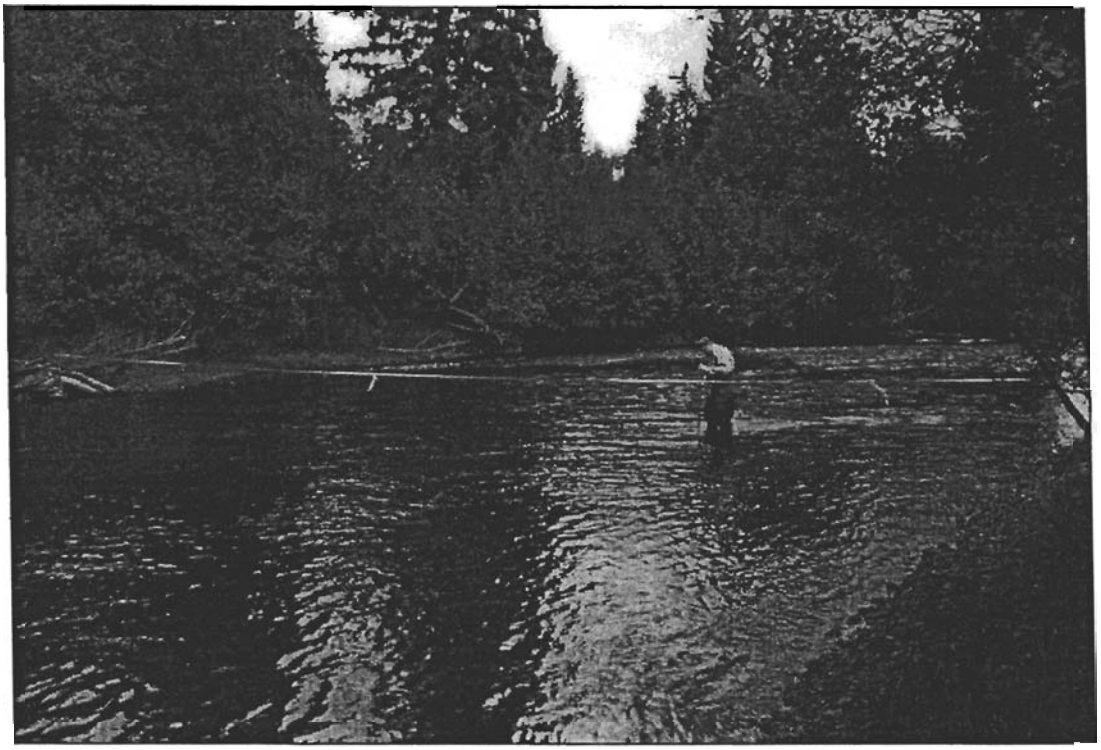

Figure 2-9. Photograph of Reach 3, Site 1, Lostine River, Oregon. Photograph taken on August 17, 1995, during flow of 111 cfs.

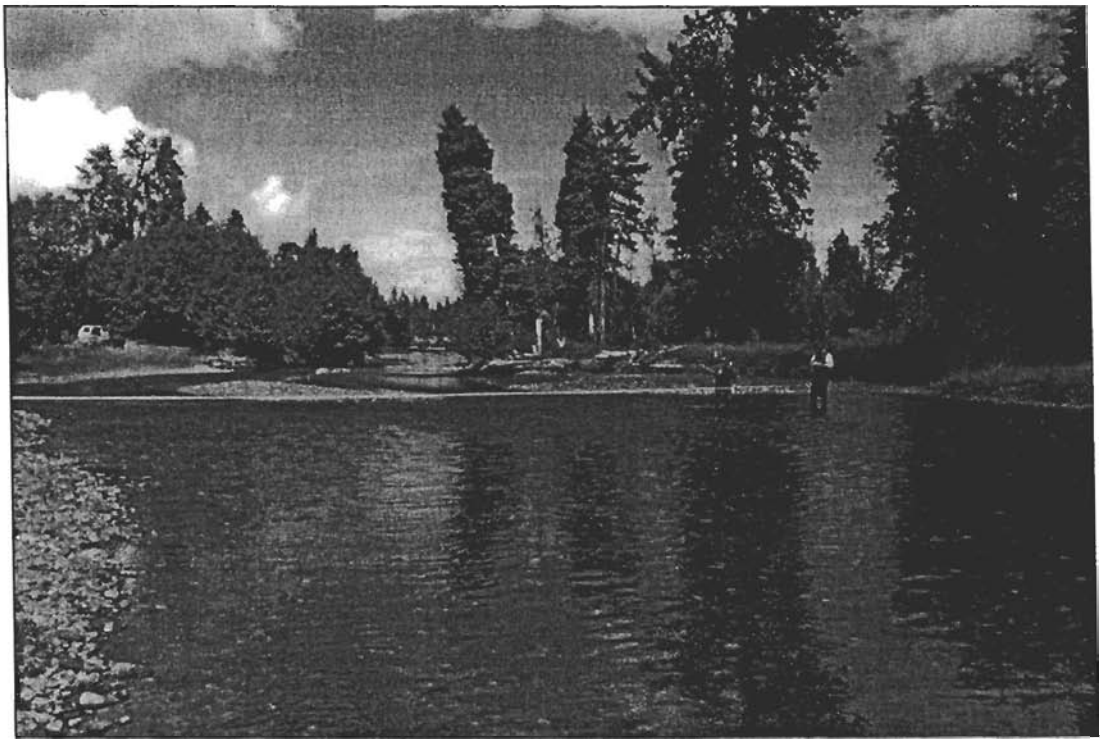

Figure 2-10. Photograph of Reach 3, Site 2, Lostine River, Oregon. Photograph taken on August 17, 1995, during flow of 111 cfs.

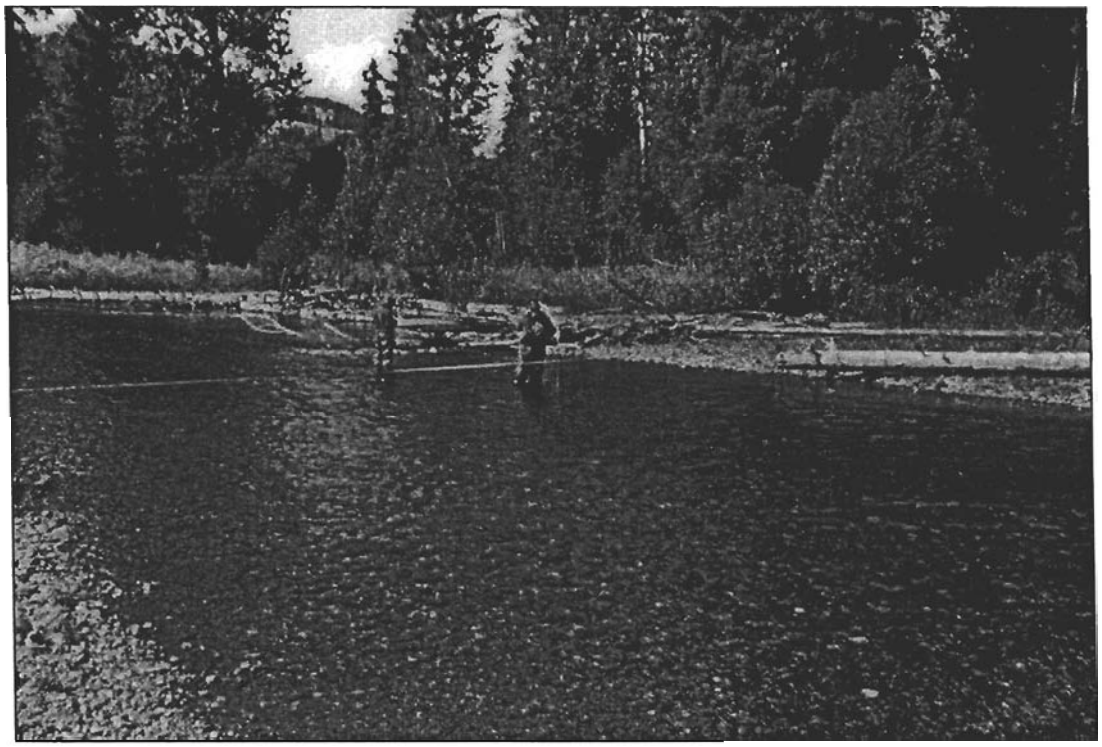

Figure 2-11. Photograph of Reach 3, Site 3, Lostine River, Oregon. Photograph taken on August 17, 1995, during flow of 111 cfs.

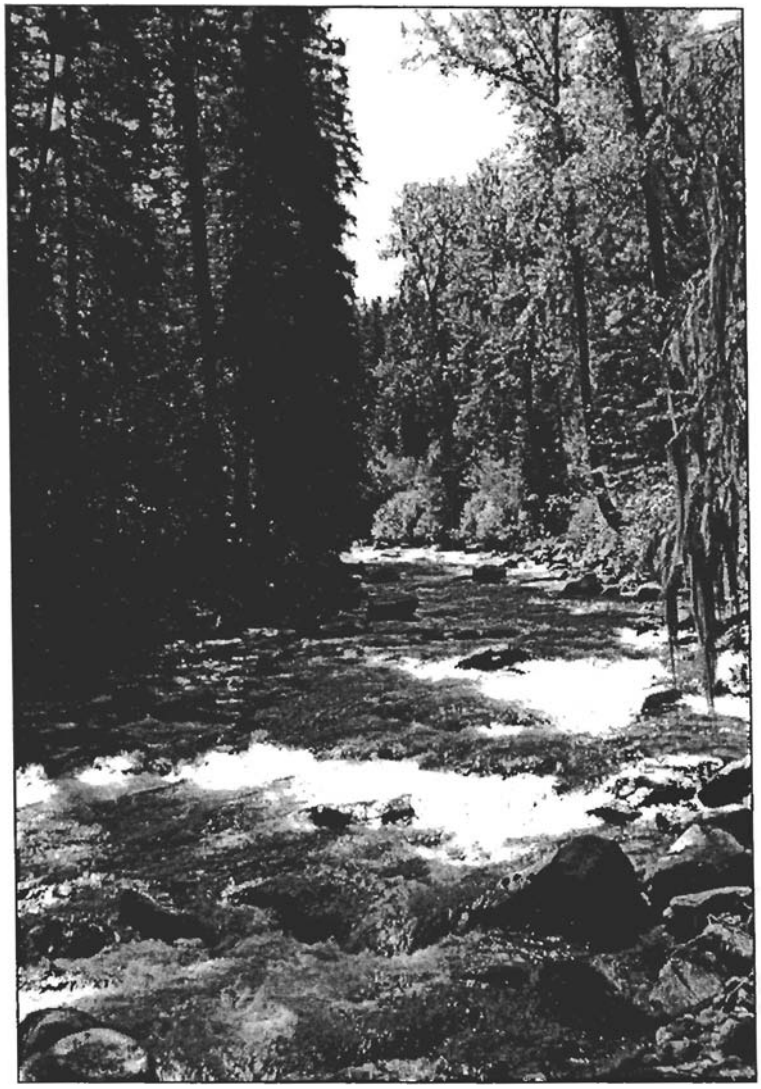

Figure 2-12. Photograph of Reach 4, Site 1, Lostine River, Oregon. Photograph taken on August 18, 1995, during flow of 93 cfs.

3. METHODS

The Physical Habitat Simulation System (PHABSIM) was employed to model hydraulic and habitat conditions in each of the four study reaches of the Lostine River. PHABSIM is a comprehensive set of microcomputer based models used to simulate habitat conditions in rivers and streams for various species and life stages of fish over a range of discharge conditions (Milhous 1979; Bovee 1982; Milhous et al. 1984). These models were used to develop habitat versus discharge relationships for fish species and life stages of concern identified by the NPT and ODFW biologists. The target fish species evaluated in this study were: 1) spring chinook salmon; 2) early fall chinook salmon; 3) coho salmon; 4) steelhead trout; 5) rainbow trout; and 6) bull trout.

The Lostine River instream flow study contained a number of related components conducted in the following order: 1) segmentation of the river into reaches; 2) establishment of representative study sites in each reach; 3) establishment of cross-sectional transects at each site; 4) measurement of stream channel and hydraulic conditions at each transect at three different flows; 5) measurements of fish habitat use within the river; 6) development of a calibrated hydraulic model for each site; 7) development of habitat suitability index (HSI) for target species and life stages from field observations and literature information; 8) habitat simulation runs using these HSI criteria and output of the hydraulic models; and 9) development of habitat versus discharge relationships for each reach.

3.1 PROJECT SCOPING

An initial site visit was conducted in August 1995 at the request of the NPT, ODFW, BOR, and BPA. The hydraulic and habitat characteristics of various reaches of the lower Lostine River were observed during this visit. A meeting was then conducted between R2 Resource Consultants, ODFW, and NPT fisheries biologists to discuss the purpose and general design of the study. Based upon this meeting, the Lostine River was initially divided into three segments or reaches, which had been previously delineated during an ODFW habitat survey conducted in the river in 1991. Based upon further discussions with NPT and ODFW biologists, the Lostine River was divided into four study reaches for the purposes of the instream flow study. These reach designations were based upon habitat characteristics, channel conditions, and hydrological conditions (including irrigation diversion impacts) in the lower Lostine River study area.

3.2 FIELD METHODS

3.2.1 Site Reconnaissance and Study Site Selection

The general location of study sites in each reach were established based upon recommendations from the ODFW and NPT fisheries biologists. The final location of these sites was determined after consulting with land owners and was contingent on gaining permission to access the river. As mentioned in Section 2, four study sites were established in Reach 1, three sites in Reaches 2 and 3, and a single site in Reach 4. Combining all reaches, a total of 11 study sites were established in the lower Lostine River.

3.2.2 Transect Selection

Four transects were placed within each IFIM study site to quantify hydraulic and habitat conditions as related to changes in flow. A total of 44 transects were placed in the Lostine River instream flow study area: four transects for each of the 11 study sites. Transect locations were established based upon the habitat types identified in each river segment during habitat surveys conducted in the Lostine River by ODFW in 1991 (see Appendix A). Due to the low flow conditions (<20 cfs) which occurred when these habitat surveys were conducted, the surveyors had a difficult time differentiating riffles from runs. Based upon observations and measurements of the relative length of riffles and runs at higher flows, these habitat types were given equal weighting during the transect selection process. Transects were established within habitat types (i.e., riffles and runs, steep riffles or rapids, and pools) which represented 10 percent or more of the habitat found within a given reach. Within each site, a transect was placed in a run, a riffle, a steep riffle or cascade (if present in the reach), and a pool.

3.2.3 Hydraulic and Habitat Measurements

The collection of physical and hydraulic measurements at each transect was completed following the general procedures outlined by Bovee and Milhous (1978), Bovee (1982), and Trihey and Wegner (1984). Depending on flow conditions, field data were collected by a field crew (2-4 individuals) having expertise in PHABSIM field methods as well as hydraulic and habitat simulation modeling procedures.

The establishment and set-up of transects occurred during initial field measurements conducted during August 1995. The establishment of transects at each location was completed as follows:

- **Locations of Transects** - Transect locations were determined as latitude and longitude using a satellite based Global Positioning System (GPS). Transect positions were recorded into a field book and then marked on a topographic map.

- **Establishment of Site Benchmark** - A permanent benchmark (BM) was established at each PHABSIM study site; this benchmark was given an arbitrary elevation datum of 100.00 ft. All survey measurements within a site, including headpin and water surface elevations, referenced this arbitrary benchmark elevation (note: several benchmarks were established within Sites 2 and 3 of Reach 2 because the distance between some transects exceeded 600 ft).

- **Installation of Head Pins** - Head pins (wooden stakes) were installed on the left side of the river at the end point of each transect. These head pins served as a vertical reference point for water surface and bed elevation measurements collected across the river channel.

- **Establishment of Working Pins** - Working pins (wooden stake, tree, fencepost) were established on either bank of a transect. The working pins were established in such a way that the line connecting these points would be perpendicular to the main flow of the river channel. A surveying tape was then stretched across the river channel and connected to these points.

- **Survey of Head Pin Elevations and Completion of Level Loop** - Subsequent to the installation of the head pins, a level loop survey was completed to establish head pin elevations. The elevation data were obtained using a Nikon 32x Automatic Level and 25-ft stadia rod with increments in 0.01-ft intervals. The level loop was considered accurate if closed to within 0.02 ft of the BM elevation,

Transect measurements were obtained under three different flow conditions (regimes) in the Lostine River: a low flow (approximately 50 cfs), a medium flow (approximately 100 cfs), and a high flow (approximately 1,000 cfs). The following data were recorded at each transect:

- **Reach Location, Study Site Location, and Transect Number** - Corresponding to the four reaches, 11 sites, and 44 transects employed in this study;

- **Habitat Type** - classified as run, riffle, steep riffle/cascade, or pool;

- **Sampling Date/Time/Investigators/Flow** - information regarding when data were collected, who collected the data, and what flow conditions were measured at USGS Gaging Station Number 13130000;

- **Elevation of Left Head Pin** - measured relative to the BM elevation;

- **Water Surface Elevations (WSEs)** - Measured to the nearest 0.01 ft. at three locations in the channel: left bank, center of channel, and right bank (note: center of channel measurements were not recorded during the high flow due to high velocities);

- **Photographs** - representative photographs were taken of each transect under each of the flow conditions.

Velocity, depth, substrate, and cover data were measured during the low and medium flow events. Only water surface elevations were measured during the high flow event (approximately 1,000 cfs) because of safety concerns. These data were collected at specified intervals (verticals) across each transect, with the number and spacing of the vertical measurements dependent on transect width and flow (note: as a general rule the verticals were spaced so that no more than 10 percent of the channel flow was located between any two verticals). The following data were collected at measurement points across the transect:

- **Bed Elevations (to nearest 0.01 ft)** - determined indirectly from water depth measurements (bed elevation = WSE - water depth);

- **Water Depth (to nearest 0.1 ft)** - measured using either a 4-ft or 6-ft top setting rod;

- **Mean Column Water Velocity (to nearest 0.1 ft/sec)** - measured using a Swoffer Model 2100 velocity meter; velocities were measured at 0.6 depth in the water column for depths less than 2.5 ft, and 0.2 and 0.8 depth in the water column for depths greater than 2.5 ft;

- **Substrate (dominant and subdominant)** - classified into boulder ($\geq$ 12 inch diameter), cobble (3.0-11.99 inch diameter), coarse gravel (1.0-2.99 inch diameter), fine gravel (0.25-0.99-inch), sand, silt, soil, and woody debris;

- **Cover** - bank cover, object cover (e.g., overhanging boulder), and woody debris cover was recorded as present or absent at each vertical across a transect.

3.2.4 Habitat Suitability Measurements

Microhabitat data were collected in the Lostine River in an attempt to develop site specific Habitat Suitability Index (HSI) curves (provided a sufficient minimum number of observations could be obtained) for target fish species, and to validate literature based curves used in the instream flow habitat simulations. Microhabitat data for young-of-year, juvenile, and adult fish were collected by underwater observation (i.e., snorkeling). Microhabitat data for spawning chinook salmon and steelhead trout were collected at redds located by walking in an upstream direction along the river. Prior to the start of either type of survey, all equipment was checked and assembled for use. This included spin test calibration of the velocity meter, and assembly of the top setting rod and wading rod. The time of day, water temperature, and water clarity were observed and recorded before each survey was initiated. Microhabitat data collection surveys were attempted during the peak of the steelhead trout spawning period during the middle of May 1996, and during yearly low flow conditions during the middle of September 1996. The collection of microhabitat data during September 1996 was restricted to Reaches 3 and 4, because irrigation withdrawals in the lower two reaches prevented effective snorkeling.

During the snorkel surveys, the field crew proceeded in an upstream direction searching for target fish species including chinook salmon, steelhead/rainbow trout, and bull trout. When two divers were working, both sides of the river were covered, with the midpoint of the river serving as the delineation point of coverage for each. When a fish was observed, a colored weight was dropped at the point of initial observation, and the snorkeler would verbally transmit information to a crew member responsible for data recording. The type of information recorded included:

- Fish species identification;
- Fish length and age class (young-of-year; juvenile; adult);
- Relative position of fish in the water column (distance from the bottom);
- Proximity to habitat structure and cover features (e.g., boulder, undercut bank, overhanging vegetation, woody debris);
- Proximity to other fish.

Only fish that maintained a fixed holding position were measured during the rnicrohabitat survey. Observations of moving fish were not documented to minimize inaccurate habitat measurements and to prevent double-counting of fish. Steelhead/rainbow trout were sometimes observed in groups of up to 50 individuals. In these situations, rnicrohabitat measurements were collected at an intermediate point within the school of fish. Fish less than four inches in total length were considered to be young-of-year fish. Fish having total lengths which equaled or exceeded four inches but less than eight inches were considered to be juveniles. Fish greater than eight inches in length were considered to be adults (this latter category applied to rainbow trout). Microhabitat measurements included:

- Water depth - measured to the nearest 0.1 ft using a top setting rod;
- Mean column velocity - measured to the nearest 0.01 ft/sec;
- Nose velocity - measured at the location of the fish in the water column;
- Substrate type - the dominant and subdominant substrate located under the fish.

To avoid "harassing" actively spawning fish, redds found during these surveys were only approached if there were no adult fish in the vicinity. When a redd was found, its location and position in the stream channel were recorded. Microhabitat measurements were then collected at the head, pit, and tail spill of each redd. These measurements included total depth, mean column velocity, and dominant and subdominant substrate type. The length and width of each redd was then measured. Only redds having definable structure (i.e., having a definite pit) were measured during the redd surveys. Disturbed gravel areas without structure (possibly "test" excavations by fish) were not measured.

3.3 DATA ANALYSIS

3.3.1 Hydraulic Simulation Modeling

Hydraulic and habitat simulation modeling were conducted using the PHABSIM Version II computer software (Milhous et al, 1989). Hydraulic simulation modeling involved the following steps:

- Raw field data were entered into Excel spreadsheets, and then were reviewed for data entry errors. Data entry errors were identified, noted in a copy of the field notebook, and corrected. These computer spreadsheets were then used to generate hydraulic data input files for the PHABSIM hydraulic simulation program IFG4. IFG4 format files were generated from the spreadsheet data using the program I4TEXT.

- The IFG4 data files were then checked for any "missed" data entry errors and erroneous field measurements using the REVI4 and CKI4 computer programs.

- Stage-discharge relationships were calibrated at each transect using several different hydraulic simulation procedures. These procedures differed among transects depending upon specific hydraulic conditions occurring at the transects. An initial stage-discharge calibration was conducted using the PHABSIM programs IFG4 and REVI4. Depending upon the hydraulic characteristics of a given transect, a stage-discharge relationships was developed using one of three methods: a log-log regression method (rating curve developed using the program STGQS4), a channel geometry and roughness method (rating curve developed using the Manning's Equation based program MANSQ), or a step-backwater method (rating curve developed using the program WSP).

- Velocities across each transect were then calibrated to provide a realistic distribution of mean column velocities across the river channel for the entire range of flows employed in habitat simulations.

- Finally, the IFG4 hydraulic simulation model was used to predict wetted width, velocity, depth, substrate, and habitat cover conditions occurring at each instream flow site for flows ranging from 5 cfs to 1,000 cfs.

A more detailed description of the hydraulic calibration procedures employed in this study are provided in Appendix B.

3.3.2 Transect and Site Weighting

Transect and site weightings employed in habitat simulation modeling were based upon results of stream surveys conducted in the Lostine River by ODFW in 1991. These habitat surveys were conducted during low flow conditions during September, and extended from the confluence of the Wallowa River (RM 0.0) to the confluence of Silver Creek (RM 13.2). Each habitat unit was classified according to type, and features of the habitat unit (e.g., length, wetted width, average depth, substrate composition, cover elements) were visually estimated by the field crew. Length,

width, and depth measurements were directly measured every 10th habitat unit. These direct measurements were then compared with visually estimated values at these same units, and used to obtain correction values for the visually estimated data obtained at the other units. The habitat classifications and lengths recorded during these 1991 surveys are provided in Appendix A.

Unfortunately, the lengths of the habitat units as measured by the ODFW in 1991 were incorrect, and underestimated the actual length of the river by 31 percent (the total survey length given in the survey was 10.1 mi, while the actual distance was 13.2 mi). Moreover, the survey crews had a difficult time discerning runs from riffles due to the low flow conditions present during the survey period. This resulted in an underestimate in the number and length of run and riffle habitat types in the Lostine River. The habitat lengths recorded during these surveys were corrected by R2 using accurate river distances obtained from USGS 7.5" series topographic maps. A correction factor was multiplied against each habitat unit length value so that the total surveyed length of the Lostine River equaled 13.2 mi (these corrected values are also provided in Appendix A). Habitat units designated as "riffles" during the original habitat survey were assumed to represent both riffles and runs. Observations of the river at higher flows (i.e., 50 to 100 cfs) indicated the habitat units originally classified as riffles were roughly 50 percent riffles and 50 percent runs.

Two levels of habitat weighting were employed in the instream flow study: transect and site. A habitat mapping approach was used in determining the weighting factors for individual transects and sites. Individual transects were provided weighting factors based upon the amount of habitat represented by that transect within a site. For example, if pools constituted 10 percent of the length of a site, then pools were assigned a weighting factor of 10 percent in PHABSIM habitat simulation runs conducted for that site. Sites were weighted according to the amount of linear habitat they represented in an entire reach. For example, a site located in a channelized section of the river would be assigned a weighting value of 30 percent if the combined length of channelized sections in a 10,000-ft-long reach was 3,000 ft. The length of channel represented by each site was calculated from the corrected 1991 ODFW habitat survey data (Appendix A).

3.3.3 Habitat Suitability Criteria

HSI curves reflect species and life stage use and preference for selected habitat parameters, including depth, velocity, and substrate (cover is also used in some models) (Bovee 1982). Depending on the extent of data available, HSI curves can be developed from the literature

(Category I curves), or from physical and hydraulic measurements made in the field over species microhabitats (Category II curves). These latter curves, when adjusted for availability (i.e., the quantity of habitat present within a given study reach) may more accurately reflect species preference (Category III curves) (Bovee 1986).

Site specific suitability curves based upon local field observations could not be developed for many of the target fish species included in the Lostine River study, for several reasons. Certain fish species were so rare (bull trout) that no microhabitat observations were collected during snorkeling surveys conducted in the river. Collecting habitat information for coho salmon was impossible because the species is presently extinct in the Snake River basin. In addition, populations of other fish species (i.e., chinook salmon) were insufficient to develop valid HSI curves. Finally, flows and turbidity levels were too high to find certain life stages of fish when that life stage was present in the river (i.e., spawning steelhead trout).

HSI curves were developed using the suitability data collected in the Lostine River, as well as fiom existing curves obtained fiom appropriate literature sources. The literature curves used for this purpose were selected based upon their applicability to habitat conditions found in the Lostine River. These curves were preferentially selected fiom small rivers and large streams in Oregon and Washington, especially those dominated by cobble and boulder substrates. However, curves fiom other areas in the western United States were also used for certain species and life stages (e.g., rainbow trout spawning) when regional curves could not be located.

HSI curves were developed primarily from literature sources when relatively few suitability observations (i.e., <100) were collected in the Lostine River for a given species and life stage (e.g., rainbow trout adults), or when no suitability data could be collected (e.g., coho salmon). In these cases, suitability data collected in the Lostine River was used to validate the curves developed from literature sources. The composite HSI curves developed fiom the literature were considered valid when the majority of data points collected in the Lostine River fell within the range of the HSI curve. For species and life stages (i.e., juvenile rainbowsteelhead trout) in which a sufficient number of suitability observations were collected (i.e., >100), HSI curves were developed primarily from the field data. In these cases, the literature HSI curves were used to broaden the field data based curves where necessary. For example, the range of velocities, depths, and substrates known to be suitable for juvenile steelhead trout was considerably greater than the range of conditions occurring in the Lostine River caused by low flows when the suitability data was collected. The HSI curves

developed under these conditions were extended using appropriate literature curves so that they could be used for modeling habitat conditions under a wide range of flows.

3.3.4 Habitat Simulation Modeling

Results of the hydraulic simulation model were used in conjunction with the HSI criteria to simulate habitat conditions for each target species and life stage over a wide range of flows (5 to 1,000 cfs). Habitat simulations were conducted using the HABTAV habitat simulation modeling program. HABTAV uses velocities obtained directly from the hydraulic model (IFG4) output files for habitat area calculations (Milhous et al. 1989). This differs from the HABTAT model, which averages velocity values between adjacent verticals for use in habitat area calculations. Because HABTAT averages velocities, it may not always realistically portray actual velocity conditions in a stream, especially when velocities among adjacent verticals are highly variable. Such is the case of the Lostine River, which is dominated by coarse bed materials which result in highly variable velocity distributions.

Weighted usable area (WUA) habitat versus discharge curves were calculated for each target fish species and life stage on a site-by-site basis. WUA is a habitat index which combines the quantity and quality of that habitat provided by alternative flows. WUA is expressed in units of square feet of habitat area per 1,000 linear ft of stream (sq-ft per 1,000 ft) (Bovee 1982; Milhous et al. 1989). It can roughly be defined as the total surface area for a 1,000-ft length of stream which possesses optimal habitat conditions (i.e., velocity, depth, substrate, cover) for a particular life-history stage.

The WUA versus habitat curves for each site were then combined to calculate the total habitat area (HA) for the entire reach. HA is used to express the total habitat area provided by a specified flow for a given stream, and is typically expressed in square feet, acres, or hectares. HA combines the amount of WUA provided among the different instream flow study sites present in a reach. The WUA values for each site are weighted by the length of reach represented by the site (the combined representative site lengths should equal the total length of the reach). HA was computed using the following relationship:

$$HA = (WUA_1 \times L_1 + WUA_2 \times L_2 + \ldots WUA_i \times L_i) / 1000$$

where

WUA_1 = WUA value for Site 1 (sq-ft per 1,000 ft);
L_1 = Representative length of Site 1 (ft);
WUA_2 = WUA value for Site 2 (sq-ft per 1,000 ft);
L_2 = Representative length of Site 2 (ft);
WUA_i = WUA for i^{th} site (sq-ft per 1,000 ft);
and
L_i = Representative length of i^{th} site.

HA values were calculated on an incremental basis for flows ranging between 5 and 1,000 cfs for each target species and life stage. These HA values were calculated using three different hydraulic models: 1) a low flow hydraulic model which was employed in habitat simulations between 5 and 50 cfs; 2) a medium flow hydraulic model which was employed in habitat simulations between 50 and 250 cfs; and 3) a high flow hydraulic model which was employed in habitat simulations between 250 and 1,000 cfs. The output of these habitat models were then combined to develop HA versus discharge relationships for the full range of flows considered in this study.

3.3.5 Upstream Passage Analysis

The low flow conditions which occur during the summer and fall in the Lostine River may prevent the successful passage of adult spring and early fall chinook salmon into upstream spawning areas. These conditions may also prevent the upstream passage of fluvial bull trout from the Wallowa River into high quality spawning areas (i.e., those possessing the cool water temperatures required by this species) located in the middle and upper reaches of the Lostine River. Passage is one of the most important factors to evaluate with respect to flow related impacts. Unsuccessful upstream passage of adult fish may result in underseeding of the river system with fry and juveniles, even though the habitat conditions for these life stages in the middle and upper reaches of the river are excellent.

We used the PHABSIM program AVPERM to analyze the potential impacts of low flow conditions in the lower reaches of the Lostine River on upstream fish passage. This program predicted depths across the river channel for flows ranging from 2 to 50 cfs in Reaches 1 and 2 of the river. The impacts of flows on upstream passage were separately analyzed for resident trout (including rainbow trout and bull trout), steelhead trout, and salmon (including coho salmon and

early fall chinook salmon). AVPERM calculated the contiguous width of the stream channel exceeding a specified minimum depth-of-passage criteria. The minimum depth criteria for upstream passage used in this analysis was 0.4 ft for resident trout, 0.6 ft for steelhead, and 0.8 ft for salmon (Thompson 1960). We assumed that these minimum depths would need to be provided across a contiguous section of the stream channel equaling or exceeding 3 ft to allow for successful upstream passage of fish. The shallowest transect (typically a riffle or cascade) within each of the IFIM study sites was used for the purpose of predicting upstream passage success as related to flow.

4. RESULTS

4.1 HYDRAULIC SIMULATION MODELING

Instream flow transect measurements were collected in the Lostine River during three flow scenarios: low flow, medium flow, and high flow. Transect measurements for the low and medium flows were obtained at different times among the four study reaches because of the variable influence of irrigation withdrawals on these reaches. Discharge values during low flow measurements ranged between 43 and 67 cfs (Table 4-1). The low flow measurements were obtained in August 1995 for Reaches 1 and 2, and in October 1995 for Reaches 3 and 4. Discharge values for medium flow measurements ranged between 93 and 154 cfs. The medium flow measurements were obtained in August 1995 for Reaches 3 and 4, in March 1996 for Reach 1, and in May 1996 for Reach 2. Finally, discharge values during high flow measurements ranged from 819 to 1,085 cfs. The high flow measurements were all obtained during June 1996. For the low and medium flows, discharges were calculated from the velocity and depth measurements obtained at the PHABSIM transects. Discharge measurements for the high flow were obtained on a site-by-site basis from USGS gage records.

Following calibration, the hydraulic model was used to simulate wetted widths, mean column velocities, and depths within each of the four reaches of the Lostine River under flows ranging from 5 to 1,000 cfs (see Appendix B for details). The wetted widths, mean velocities, and mean depths predicted by the hydraulic model for flows of 10, 100, and 1,000 cfs at each transect are presented in Table 4-2 (Reach 1), Table 4-3 (Reach 2), Table 4-4 (Reach 3), and Table 4-5 (Reach 4).

4.2 HABITAT COMPOSITION BY SITE AND REACH

Habitat types within the four study reaches of the Lostine River were delineated from the corrected results of the habitat survey conducted by ODFW in 1991. The representative length of individual habitat types in each reach are summarized in Table 4-6, while the percentage of habitat contributed by each habitat type is summarized in Table 4-7. Reach 1 possessed a higher percentage of rapid/cascade habitat than the other three reaches, a result of confined channel widths and riprap debris accumulations in the channelized sections of this reach. Only 8 percent of Reach 1 was pool habitat. The amount of pool habitat present in Reach 2 was slightly higher than that in Reach 1. Reach 3 contained more pools and less riffle/run habitat than the preceding

reaches. Finally, Reach 4 was dominated by rapidslcascades due to steep gradients, narrow channel widths, and the presence of large boulders (Table 4-7).

4.3 HABITAT SUITABILITY CRITERIA

The habitat suitability criteria employed in habitat simulations were developed using site-specific data and literature derived HSI curves. Microhabitat data were obtained in the Lostine River for spring chinook salmon spawning, young-of-year steelhead/rainbow trout, juvenile steelhead/rainbow trout, juvenile chinook salmon, and adult rainbow trout. These data were collected in Reaches 3 and 4 during the week of September 16, 1996. Flows within these two reaches during this period (as measured at USGS Gage 13330000) ranged from 60 to 68 cfs (USGS 1997). Flows were too low (<20 cfs) in Reaches 1 and 2 during this period for snorkeling. Redd surveys were also conducted from May 8 through May 10, 1996, during the peak of the summer steelhead spawning season. However, no fish or redds were observed in any of the study reaches during this time period. The final HSI curves developed for the Lostine River are provided in Appendix C.

4.3.1 Chinook Salmon

No chinook salmon fry were observed in the Lostine River during the microhabitat surveys. The HSI criteria were derived from microhabitat studies conducted in the Yakima River by Stempel (1984), habitat utilization curves developed for the Trinity River, California by Hampton (1988), and habitat utilization curves developed in the Sandy River, Oregon (Beak 1985).

Only 7 juvenile chinook salmon were observed in the Lostine River during the microhabitat surveys. These fish were observed in Reach 3 at depths between 1.2 and 2.0 ft. and at mean column velocities between 0.4 and 0.9 fps. These fish were observed in proximity to cobble and boulder substrates.

A total of 17 spring chinook redds were observed in Reach 3 of the Lostine River during September 1996. Six adult spring chinook salmon were also observed holding in deep pools in this reach during the September 1996 survey. The depths of spring chinook redds in this reach (measured at the pit) ranged from 0.3 to 2.0 ft, with peak utilization between 0.8 and 1.0 ft (Figure 4-1). Mean column velocities over the redds ranged from 0.5 to 3.5 fps, with peak utilization between 1.0 and 2.0 fps. These redds were located in substrates dominated by fine and

coarse gravels (Figure 4-1). The HSI curves for spring chinook salmon were derived from these data, as well as suitability data collected in the Willamette River drainage, Oregon (Sams and Pearson 1963), and HSI curves developed in the Yakima River, Washington (Stempel 1984).

Because of their larger size, early fall chinook salmon were considered to use faster water and larger substrates than spring chinook salmon. HSI curves for early fall chinook salmon were derived from a study conducted on the Wenatchee River, Washington (Arnsberg et al. 1992), the Willamette River drainage, Oregon (Sams and Pearson 1963), and the Sandy River, Oregon (Beak 1985).

4.3.2 Coho Salmon

The HSI criteria for coho salmon fry and juveniles were obtained from habitat utilization curves obtained in the Trinity River, California (Hampton 1988). Curves for coho salmon spawning were derived from curves developed in the Willamette River drainage and coastal Oregon (Sarns and Pearson 1963), in the Trinity River, California (Hampton 1988), and in British Columbia (Bustard and Narver 1975).

4.3.3 Steelhead and Rainbow Trout

A total of 40 steelheadlrainbow trout fry were observed in Reaches 3 and 4 during the microhabitat surveys. Juvenile fish were observed at depths between 2.0 and 6.0 ft, and at mean column velocities between 0.3 and 1.0 fps (Figure 4-2). These fish used substrates ranging from sand to small cobbles. HSI criteria for this life stage were derived from utilization curves developed in the Sandy River, Oregon (Beak 1985), in the Trinity River, California (Hampton 1988), in Rock Creek (Shasta County), California (Baltz et al. 1991), and in the eastern Sierra Nevada Mountains (Smith and Aceituno 1987).

A total of 361 juvenile steelheadlrainbow trout were observed during the Lostine River microhabitat surveys. Juvenile fish were observed to use depths ranging from 1.0 to 10.0 ft, with peak use observed between 5.0 and 6.0 ft. (Figure 4-3). Mean column velocities used by these fish ranged from 0.0 to 1.0 fps, with peak utilization observed between 0.0 and 0.3 fps. Juvenile steelheadlrainbow trout used a wide range of substrates, with peak utilization observed over silt and boulder substrates (Figure 4-3). HSI criteria for juvenile steelheadlrainbow trout were developed from these data, and were broadened using curves developed in Colorado (Thomas and

Bovee 1991), in the Sandy River, Oregon (Beak 1985), in the Trinity River, California (Hampton 1988), in Rock Creek, California (Batz et al. 1991), and in the eastern Sierra Nevada Mountains (Smith and Aceituno 1987). The HSI curves developed from microhabitat data collected in the Lostine River required modification due to the low flow conditions (< 70 cfs) occurring in Reaches 3 and 4 during the September 1996 snorkel survey period. The maximum velocities observed throughout these reaches were generally much lower than the upper range of velocities (~4 fps; Thomas and Bovee 1991) known to be suitable for rainbow trout.

A total of 12 adult rainbow trout were observed during the Lostine River microhabitat surveys. These fish used depths between 0.5 and 10.0 ft (peak utilization between 2.0 and 4.0 ft), velocities ranging from 0.0 to 1.5 fps (peak utilization between 0.75 and 1.0 fps), and substrate sizes ranging from sand to boulders (peak utilization observed in proximity to boulders) (Figure 4-4). HSI criteria for adult rainbow trout were derived from utilization curves developed in Colorado (Thomas and Bovee 1991), in Rock Creek, California (Baltz et al. 1991), and in the eastern Sierra Nevada Mountains (Smith and Aceituno 1987).

HSI criteria for rainbow trout spawning were derived from curves developed in the Beaverhead River, Montana (Sando 1981), the Yellowstone River, Montana (Spoon 1985), and in the eastern Sierra Nevada Mountains (Smith and Aceituno 1987). HSI criteria for steelhead trout spawning were derived from curves developed in the Willamette River drainage, Oregon (Sarns and Pearson 1963), the Sandy River, Oregon (Beak 1985), and in the Trinity River, California (Hampton 1988).

4.3.4 Bull Trout

No bull trout were observed during microhabitat surveys conducted in the Lostine River. HSI criteria for bull trout fry were constructed from rnicrohabitat observation recorded in the Flathead River drainage, Montana (Shepard et al. 1984). HSI criteria for bull trout juveniles were derived from utilization curves developed in the Flathead River drainage (Pratt 1984), and from microhabitat data recorded in a number of streams in Idaho (Bonneau 1994). No HSI criteria or microhabitat data could be found in the literature for adult bull trout. HSI criteria for this life stage were adapted from the juvenile curve; adult fish were assumed to use higher velocities than juvenile fish. HSI criteria for bull trout spawning were derived from utilization curves developed in the upper Flathead River drainage (Pratt 1984), and in the Cedar River, Washington (Reiser et al. 1997).

4.4 HABITAT VERSUS FLOW RELATIONSHIPS

Weighted usable area (WUA) versus discharge curves were developed at each study site, and then combined based upon site weighting values to calculate total habitat area (HA) curves for the entire reach. The WUA and HA values calculated for Reaches 1 through 4 are provided in Appendices D through G, respectively. Two flow values are presented for each species and life stage in this section: the flow resulting in the maximum HA value (i.e., peak of curve), and the flow resulting in 50 percent of the maximum HA value. The maximum HA value is that which provides optimal habitat conditions to a given species and life stage, while 50 percent of maximum is a provisional target value which provides good habitat conditions to the same species and life stage.

4.4.1 Reach 1-Wallowa River to Cross-Country Ditch

Habitat area (HA) values for spring and early fall chinook salmon spawning in Reach 1 increased rapidly at flows greater than 50 cfs (Figure 4-5). The maximum HA value for both spring and early fall chinook salmon spawning in this reach occurred at 120 cfs (Table 4-8). A flow of 45 cfs provided 50 percent of the maximum HA value for spring chinook salmon, and a flow of 55 cfs provided 50 percent of the maximum HA value for early fall chinook salmon (Table 4-9). Peak HA values for chinook salmon fry and juveniles in this reach occurred at flows of 50 and 55 cfs respectively (Figure 4-5; Table 4-8). Flows of 5 and 15 cfs provided 50 percent of the maximum HA value for fry and juvenile chinook salmon, respectively.

The maximum HA value for coho salmon spawning in Reach 1 occurred at 80 cfs (Figure 4-6; Table 4-8). Maximum HA values for coho fry and juveniles in the reach occurred at 50 cfs (Figure 4-6; Table 4-8). Flows of 5 and 10 cfs provided 50 percent of the maximum HA value for fry and juvenile coho salmon, respectively (Table 4-9).

The maximum HA value for steelhead trout spawning in Reach 1 occurred at 140 cfs (Figure 4-6; Table 4-8). The maximum HA value for rainbow trout spawning in Reach 1 occurred at 350 cfs (Figure 4-6; Table 4-8). A flow of 60 cfs provided 50 percent of the maximum HA value for spawning steelhead trout, while a flow of 80 cfs provided 50 percent of the maximum HA value for spawning rainbow trout (Table 4-9). Maximum HA values for steelhead fry and juveniles in this reach occurred at 25 and 50 cfs, respectively. Flows of 5 and 25 cfs provided 50 percent of the maximum HA values for steelhead/rainbow trout fry and juveniles, respectively (Table 4-9).

The maximum HA value for adult rainbow trout occurred at 120 cfs (Figure 4-7; Table 4-8), while 50 percent of the maximum HA value for adult rainbow trout occurred at 45 cfs (Table 4-9).

The maximum HA value for spawning bull trout in Reach 1 occurred at 65 cfs (Figure 4-8; Table 4-8), while a flow of 20 cfs provided 50 percent of the maximum HA value for spawning bull trout (Table 4-9). Flows of 15 and 65 cfs provided the maximum HA value for fry and juvenile bull trout, respectively (Figure 4-8; Table 4-8). Flows of 5 and 20 cfs provided 50 percent of the maximum HA value for the fry and juvenile life stages, respectively (Table 4-9). A flow of 90 cfs provided the maximum HA value for adult bull trout in this reach (Figure 4-8; Table 4-8), while a flow of 35 cfs provided 50 percent of the maximum value for this life stage (Table 4-9).

4.4.2 Reach 2—Cross-Country Ditch to Westside Ditch

The maximum HA values for spring and early fall chinook salmon spawning in Reach 2 occurred at flows of 450 and 500 cfs, respectively (Figure 4-9; Table 4-8). **A** flow of 250 cfs provided 50 percent of the maximum HA value for both spring and early fall chinook salmon spawning in this reach (Table 4-9). Peak HA values for chinook salmon fry and juveniles in this reach occurred at flows of 15 and 25 cfs respectively (Figure 4-9; Table 4-8). Flows of 5 cfs provided 50 percent of the maximum HA value for both fry and juvenile chinook salmon (Table 4-9).

The maximum HA value for coho salmon spawning in Reach 2 occurred at 350 cfs (Figure 4-10; Table 4-8). A flow of 130 cfs provided 50 percent of the maximum HA value for coho salmon spawning in this reach (Table 4-9). Maximum HA values for coho fry and juveniles in the reach occurred at 5 and 25 cfs, respectively (Figure 4-10; Table 4-8). Flows of 5 cfs provided 50 percent of the maximum HA value for both fry and juvenile coho salmon (Table 4-9).

The maximum HA value for steelhead trout spawning in Reach 2 occurred at 600 cfs (Figure 4-11; Table 4-8). The maximum HA value for rainbow trout spawning in Reach 2 occurred at 800 cfs (Figure 4-11; Table 4-8). A flow of 300 cfs provided 50 percent of the maxirnum HA value for spawning steelhead trout, while a flow of 350 cfs provided 50 percent of the maxirnum HA value for spawning rainbow trout (Table 4-9). Maximum HA values for steelhead fry and juveniles in this reach occurred at 15 and 45 cfs, respectively (Figure 4-11; Table 4-8). Flows of 10 and 25 cfs provided 50 percent of the maximum HA values steelhead/rainbow trout fry and juveniles, respectively (Table 4-9). The maximum HA value for adult rainbow trout occurred at 100 cfs

(Figure 4-11; Table 4-8), while 50 percent of the maximum HA value for adult rainbow trout occurred at 25 cfs (Table 4-9).

The maximum HA value for spawning bull trout in Reach 2 occurred at 350 cfs (Figure 4-12; Table 4-8), while a flow of 170 cfs provided 50 percent of the maximum HA value for spawning bull trout (Table 4-9). Flows of 5 and 45 cfs provided the maximum HA value for fry and juvenile bull trout, respectively (Figure 4-12; Table 4-8). Flows of 5 cfs provided 50 percent of the maximum HA value for both the fry and juvenile life stages (Table 4-9). A flow of 130 cfs provided the maximum HA value for adult bull trout in this reach (Figure 4-12; Table 4-8), while a flow of 20 cfs provided 50 percent of the maximum HA value for this life stage (Table 4-9).

4.4.3 Reach 3-Westside Ditch to Highway 551 Bridge

The maximum HA values for spring and early fall chinook salmon spawning in Reach 3 occurred at flows of 300 and 180 cfs, respectively (Figure 4-13; Table 4-8). Flows of 55 and 65 cfs provided 50 percent of the maximum HA value for both spring and early fall chinook salmon, respectively (Table 4-9). Peak HA values for chinook salmon fry and juveniles in this reach occurred at flows of 25 and 65 cfs, respectively (Figure 4-13; Table 4-8). Flows of 5 cfs provided 50 percent of the maximum HA value for both fry and juvenile chinook salmon (Table 4-9).

The maximum HA value for coho salmon spawning in Reach 3 occurred at 90 cfs (Figure 4-14; Table 4-8). A flow of 25 cfs provided 50 percent of the maximum HA value for coho salmon spawning in this reach (Table 4-9). Maximum HA values for coho fry and juveniles in the reach occurred at 10 and 70 cfs, respectively (Figure 4-14; Table 4-8). Flows of 5 cfs provided 50 percent of the maximum HA value for both fry and juvenile coho salmon (Table 4-9).

The maximum HA value for steelhead trout spawning in Reach 3 occurred at 300 cfs (Figure 4-15; Table 4-8). The maximum HA value for rainbow trout spawning in Reach 3 occurred at 400 cfs (Figure 4-15; Table 4-8). A flow of 80 cfs provided 50 percent of the maximum HA value for spawning steelhead trout, while a flow of 95 cfs provided 50 percent of the maximum HA value for spawning rainbow trout (Table 4-9). Maximum HA values for steelhead fry and juveniles in this reach occurred at 25 and 90 cfs, respectively (Figure 4-15; Table 4-8). Flows of 20 and 50 cfs provided 50 percent of the maximum HA values steelhead/rainbow trout fry and juveniles, respectively (Table 4-9). The maximum HA value for adult rainbow trout occurred at 300 cfs

(Figure 4-15; Table 4-8), while 50 percent of the maximum HA value for adult rainbow trout occurred at 50 cfs (Table 4-9).

The maximum HA value for spawning bull trout in Reach 3 occurred at 100 cfs (Figure 4-16; Table 4-8), while a flow of 20 cfs provided 50 percent of the maximum HA value for spawning bull trout (Table 4-9). Flows of 10 and 85 cfs provided the maximum HA value for fry and juvenile bull trout, respectively (Figure 4-16; Table 4-8). Flows of 5 and 10 cfs provided 50 percent of the maximum HA value the fry and juvenile life stages, respectively (Table 4-9). A flow of 140 cfs provided the maximum HA value for adult bull trout in this reach (Figure 4-16; Table 4-8), while a flow of 25 cfs provided 50 percent of the maximum HA value for this life stage (Table 4-9).

4.4.4 Reach 4-Highway 551 Bridge to Pole Bridge

The maximum HA value for both spring and early fall chinook salmon spawning in Reach 4 occurred at a flow of 300 cfs (Figure 4-17; Table 4-8). Flows of 130 and 120 cfs provided 50 percent of the maximum HA value for both spring and early fall chinook salmon, respectively (Table 4-9). Peak HA values for chinook salmon fry and juveniles in this reach occurred at flows of 65 and 95 cfs, respectively (Figure 4-17; Table 4-8). Flows of 10 and 15 cfs provided 50 percent of the maximum HA value for fry and juvenile chinook salmon, respectively (Table 4-9).

The maximum HA value for coho salmon spawning in Reach 4 occurred at 200 cfs (Figure 4-18; Table 4-8). A flow of 50 cfs provided 50 percent of the maximum HA value for coho salmon spawning in this reach (Table 4-9). Maximum HA values for coho fry and juveniles in the reach occurred at 25 and 80 cfs, respectively (Figure 4-18; Table 4-8). Flows of 5 and 10 cfs provided 50 percent of the maximum HA value the fry and juvenile life stages, respectively (Table 4-9).

The maximum HA value for steelhead and rainbow trout spawning in Reach 4 occurred at 350 cfs (Figure 4-19; Table 4-8). A flow of 170 cfs provided 50 percent of the maximum HA value for spawning steelhead trout, while a flow of 250 cfs provided 50 percent of the maximum HA value for spawning rainbow trout (Table 4-9). Maximum HA values for steelhead fry and juveniles in this reach occurred at 30 and 80 cfs, respectively (Figure 4-19; Table 4-8). Flows of 5 and 15 cfs provided 50 percent of the maximum HA values steelhead/rainbow trout fry and juveniles, respectively (Table 4-9). The maximum HA value for adult rainbow trout occurred at 200 cfs

(Figure 4-19; Table 4-8), while a flow of 30 cfs provided 50 percent of the maximum HA value for this life stage (Table 4-9).

The maximum HA value for spawning bull trout in Reach 4 occurred at 200 cfs (Figure 4-20; Table 4-8), while a flow of 55 cfs provided 50 percent of the maximum HA value for this life stage (Table 4-9). Flows of 25 and 55 cfs provided the maximum HA value for fry and juvenile bull trout, respectively (Figure 4-20; Table 4-8). Flows of 5 and 10 cfs provided 50 percent of the maximum HA value for fry and juvenile life stages, respectively (Table 4-9). A flow of 180 cfs provided the maximum HA value for adult bull trout in this reach (Figure 4-20; Table 4-8), while a flow of 25 cfs provided 50 percent of the maximum HA value for this life stage (Table 4-9).

4.5 UPSTREAM PASSAGE

Minimum flows ranging from 2 to 6 cfs were predicted to be required for successful upstream passage of resident trout ranged in Reach 1 (Figure 4-21). A riffle within Site 3 of this reach was found to impose the greatest passage limitation for resident trout, with a flow of 6 cfs required for upstream passage through this riffle. In comparison, minimum flows between 8 and 16 cfs were predicted to be required to allow for upstream passage of steelhead trout in Reach 1 (Figure 4-21). The highest minimum flow requirement for steelhead passage (16 cfs) was also observed in a riffle located within Site 3. Finally, minimum flows between 20 and 40 cfs were predicted to be required for upstream passage of salmon within Reach 1 (Figure 4-21). A shallow riffle located within Site 1 was found to have the highest minimum flow passage requirement (40 cfs) for salmon in this reach.

Passage flows in Reach 2 were less than those in Reach 1, a result of the narrower and deeper channel in the former reach. The minimum flows required to allow for upstream passage of resident trout in Reach 2 ranged from 1 and 4 cfs among the three study sites located in this reach (Figure 4-22). A shallow riffle located within Site 1 was predicted to require the highest flow for upstream passage (4 cfs). For steelhead trout, minimum flows ranging from 2 and 14 cfs were found to be required for upstream passage in Reach 2 (Figure 4-22). The highest minimum flow required to provide passage among the three study sites (14 cfs) was within the same shallow riffle in Site 1. Flows ranging from 4 and 28 cfs were predicted to be required to allow for upstream passage of salmon in Reach 2 (Figure 4-22). The highest minimum flow requirement (28 cfs) for upstream passage of salmon was within the same shallow riffle in Site 1.

We assumed that the highest minimum flow predicted among all the transects located within a given reach would be the flow required to allow for the successful passage through the entire reach. Given this assumption, the minimum flows required to allow for upstream passage in Reach 1 were predicted as:

- Resident trout (rainbow and bull trout): 4 cfs
- Steelhead trout: 16 cfs
- Salmon (spring and early fall chinook salmon, coho salmon): 40 cfs

The minimum flows required to allow for upstream passage in Reach 2 were predicted as:

- Resident trout (rainbow and bull trout): 6 cfs
- Steelhead trout: 14 cfs
- Salmon (spring and early fall chinook salmon, coho salmon): 28 cfs

To allow for upstream passage through the two lower reaches of the Lostine River into the upper reaches of this river, minimum flows of 6 cfs would be required for resident trout, 16 cfs would be required for steelhead trout, and 40 cfs would be required for salmon.

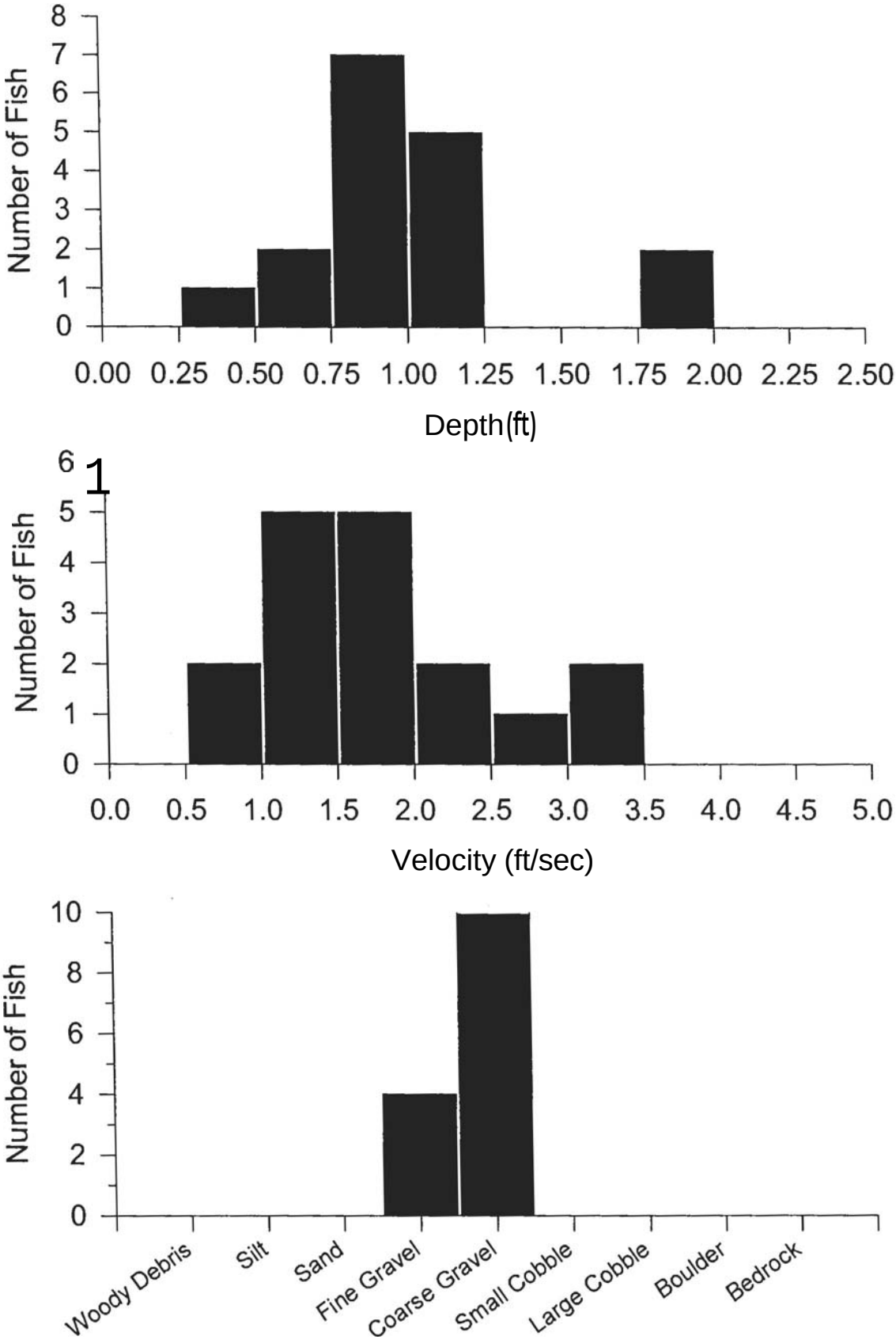

Figure 4-1. Depth, velocity, and substrate utilization histograms for spawning spring chinook salmon observed in the Lostine River, Oregon in September 1996 (n = 17).

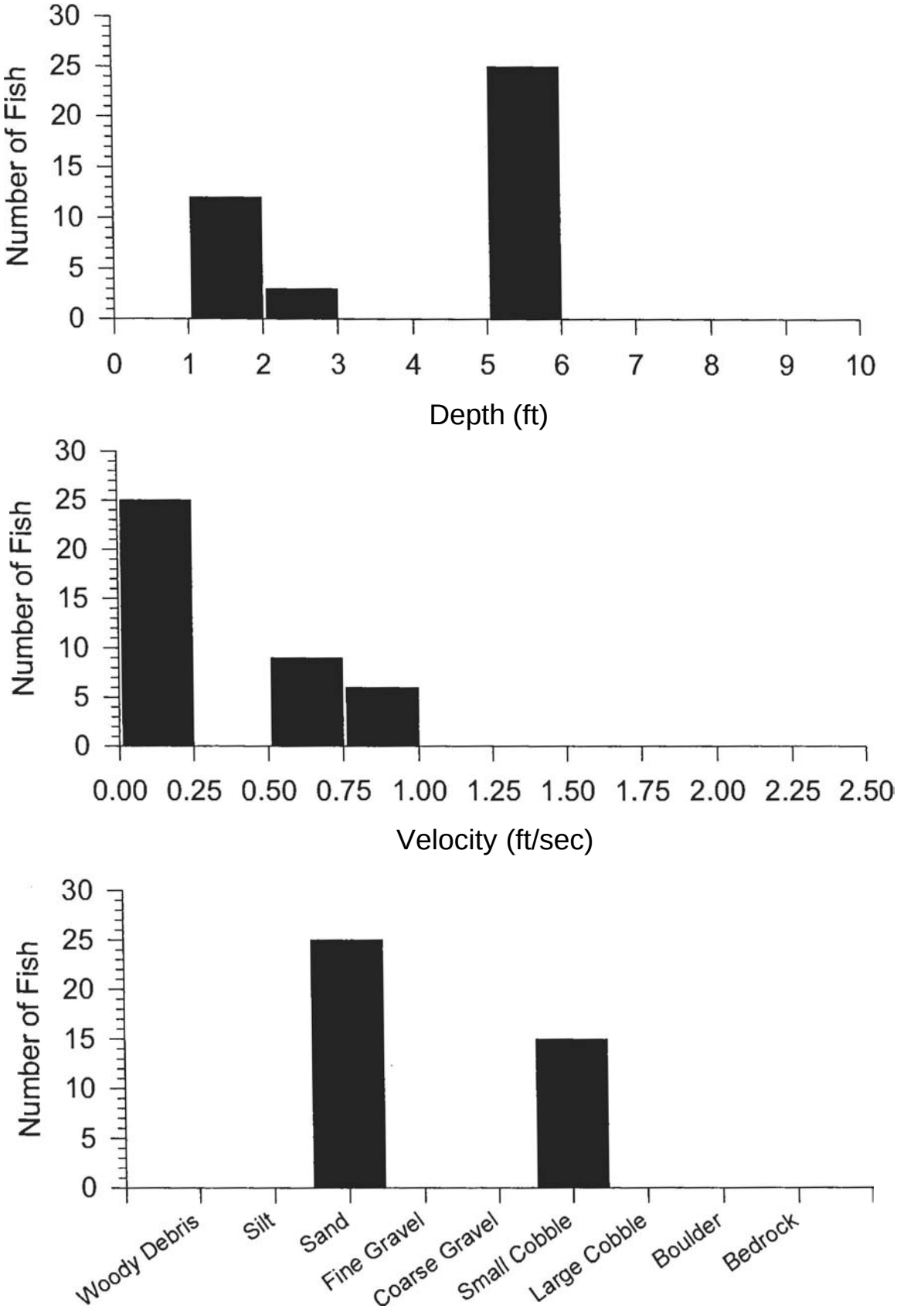

Figure 4-2. Depth, velocity, and substrate utilization histograms for young of year rainbow and steelhead trout observed in the Lostine River, Oregon in September 1996 (n = 40).

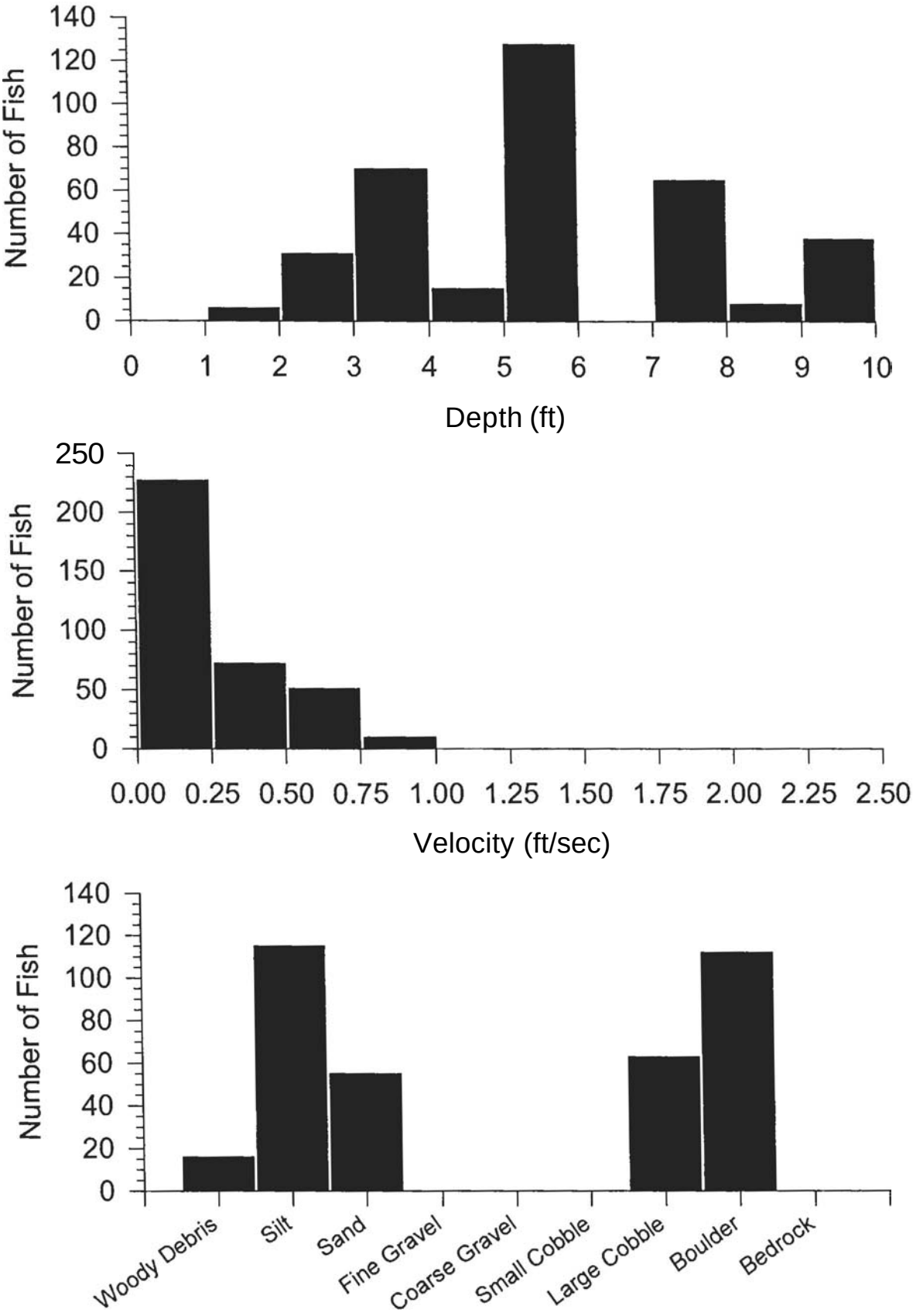

Figure 4-3. Depth, velocity, and substrate utilization histograms for juvenile rainbow and steelhead trout observed in the Lostine River, Oregon in September 1996 (n = 361).

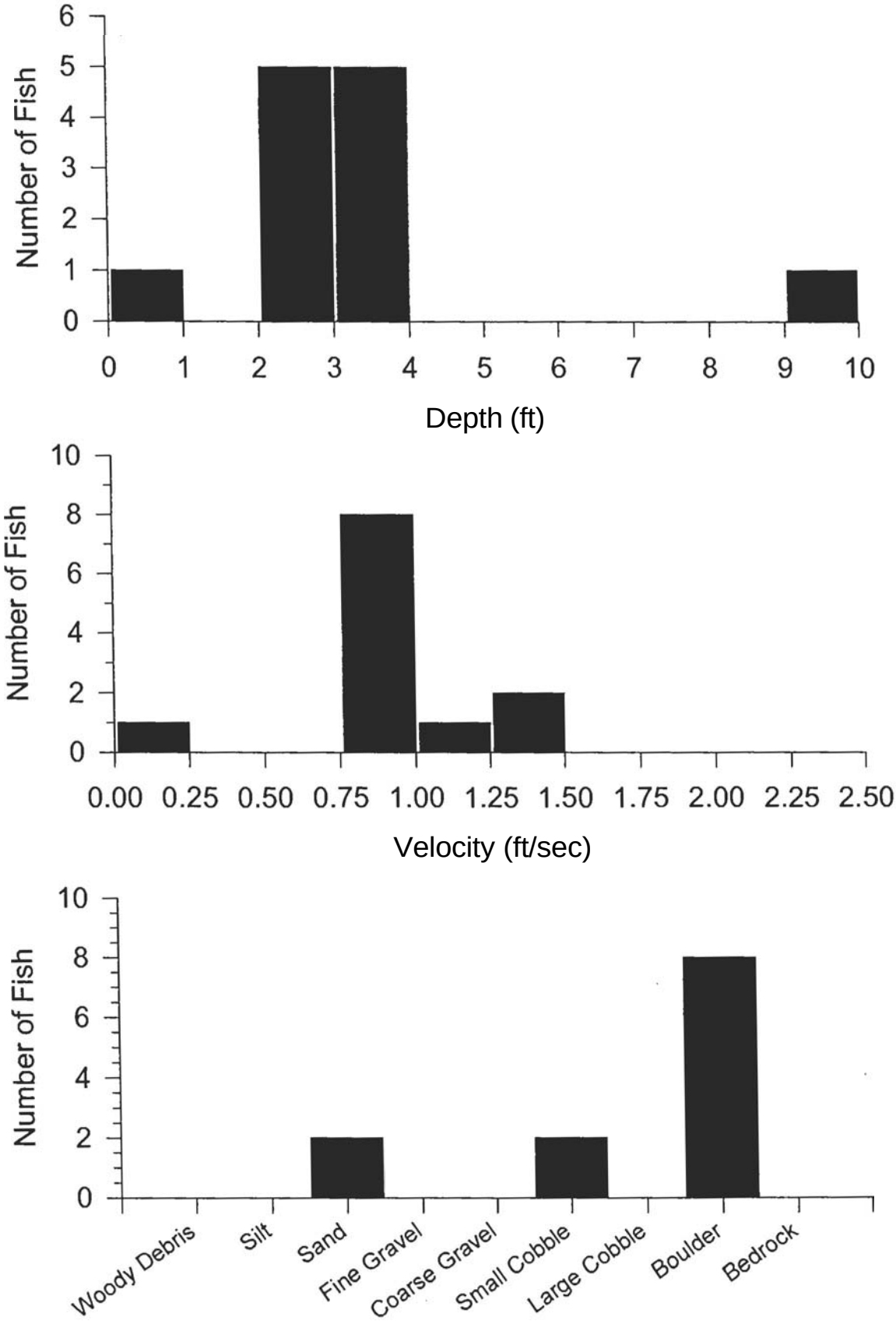

Figure 4-4. Depth, velocity, and substrate utilization histograms for adult rainbow trout observed in the Lostine River, Oregon in September 1996 (n = 12).

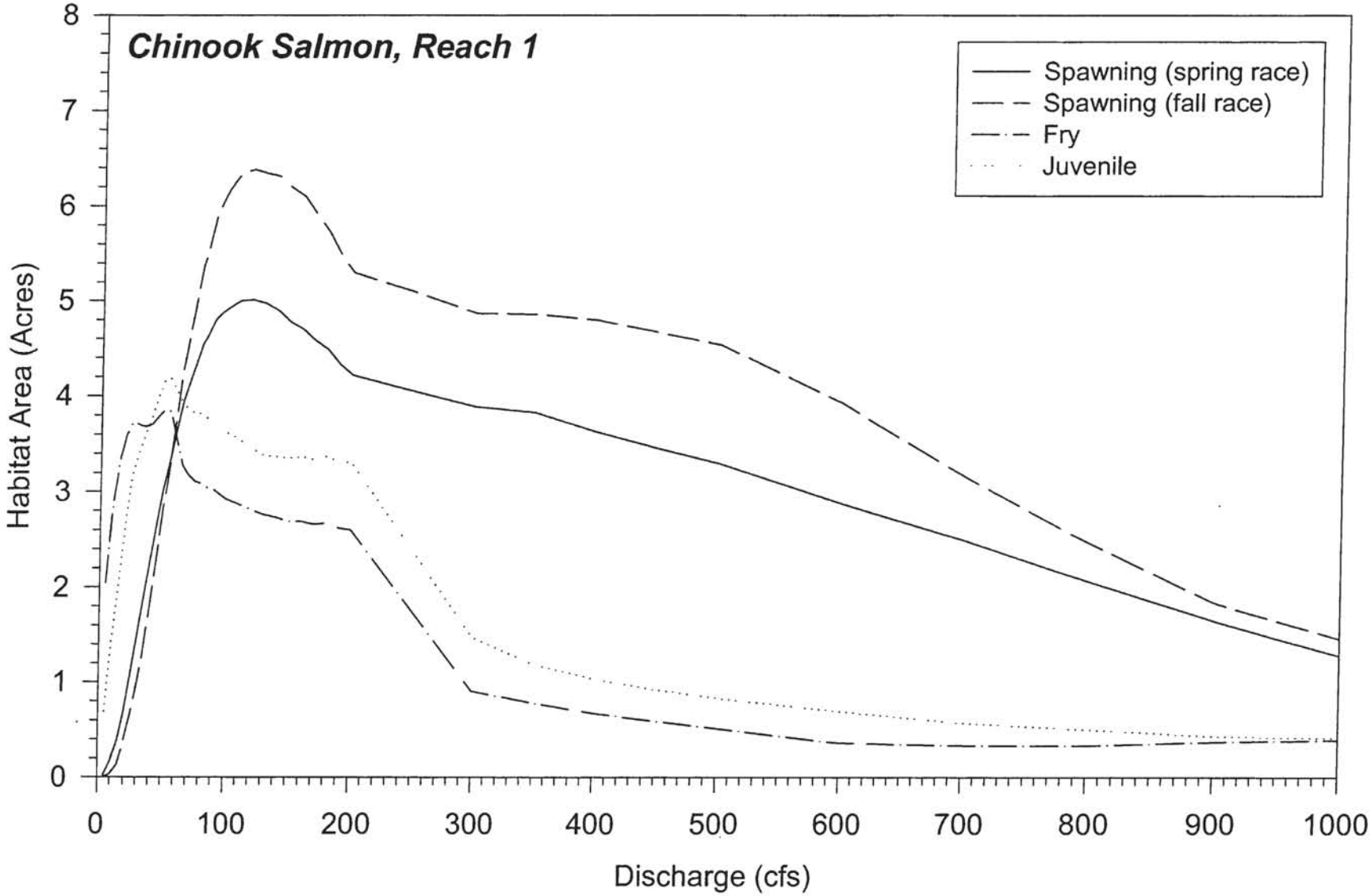

Figure 4-5. Chinook salmon total habitat area (HA) versus discharge relationships for Reach 1, Lostine River, Oregon.

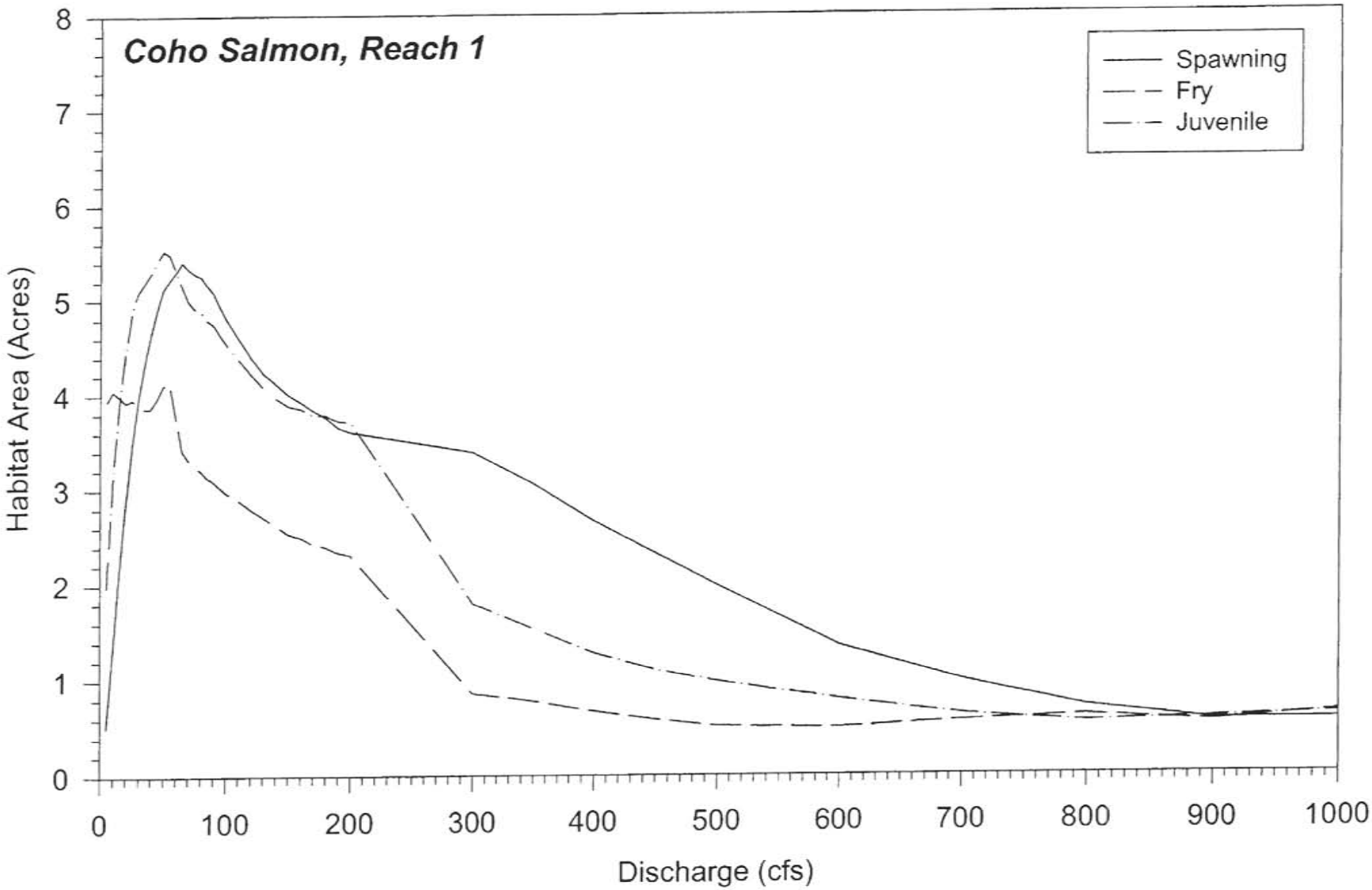

Figure 4-6. Coho salmon total habitat area (HA) versus discharge relationships for Reach 1, Lostine River, Oregon.

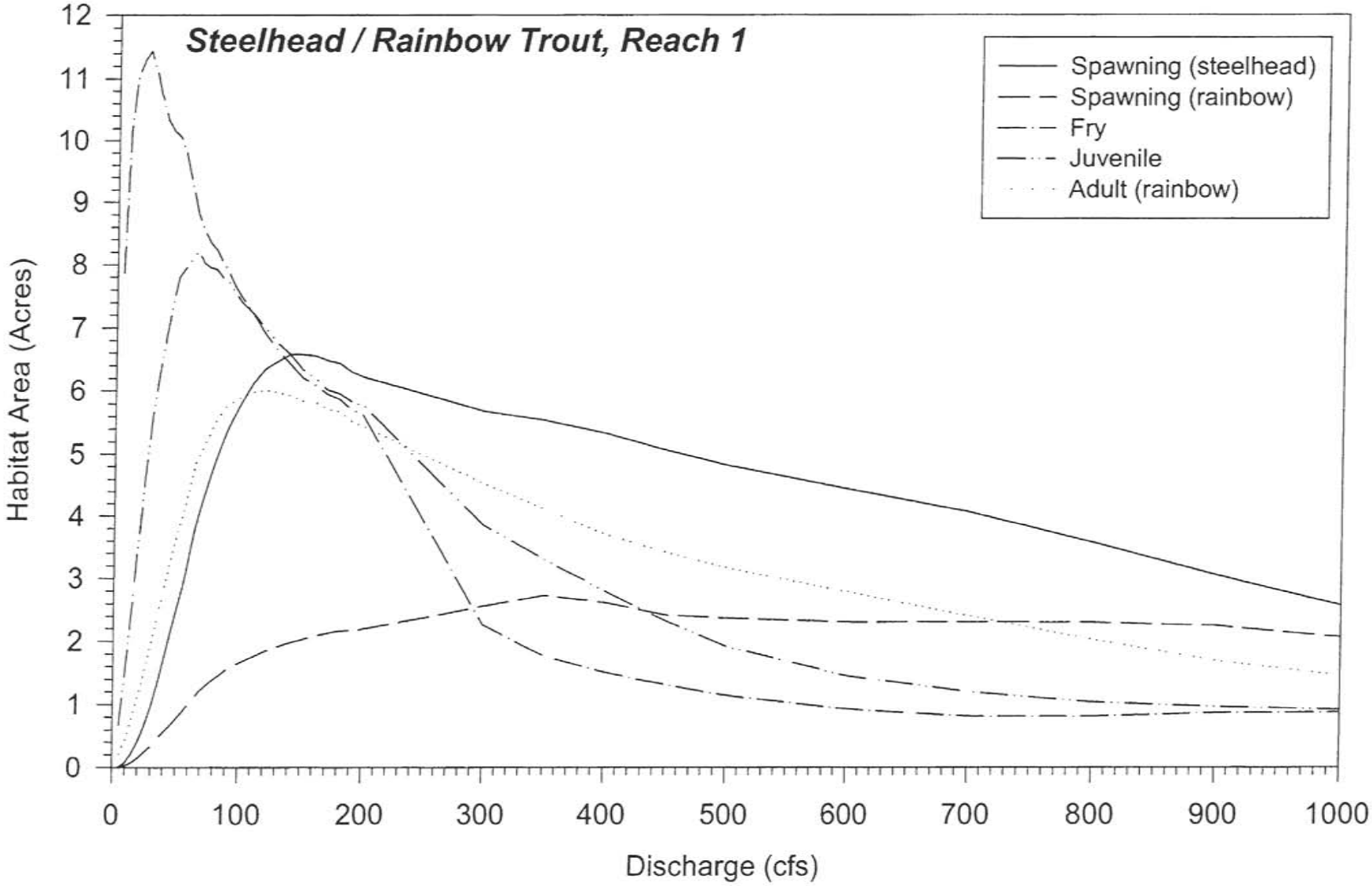

Figure 4-7. Steelhead and rainbow trout total habitat area (HA) versus discharge relationships for Reach 1, Lostine River, Oregon.

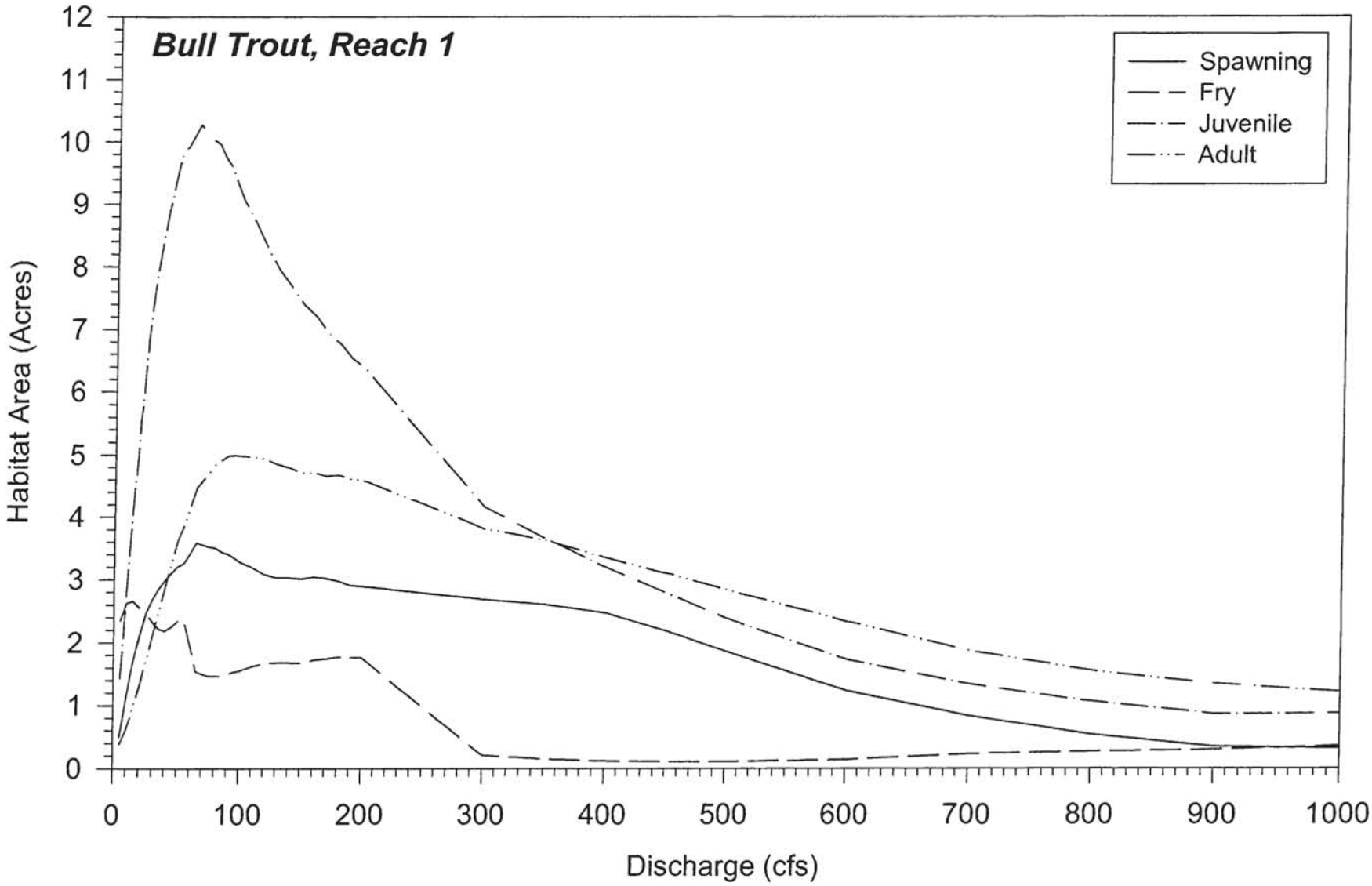

Figure 4-8. Bull trout total habitat area (HA) versus discharge relationships for Reach 1, Lostine River, Oregon.

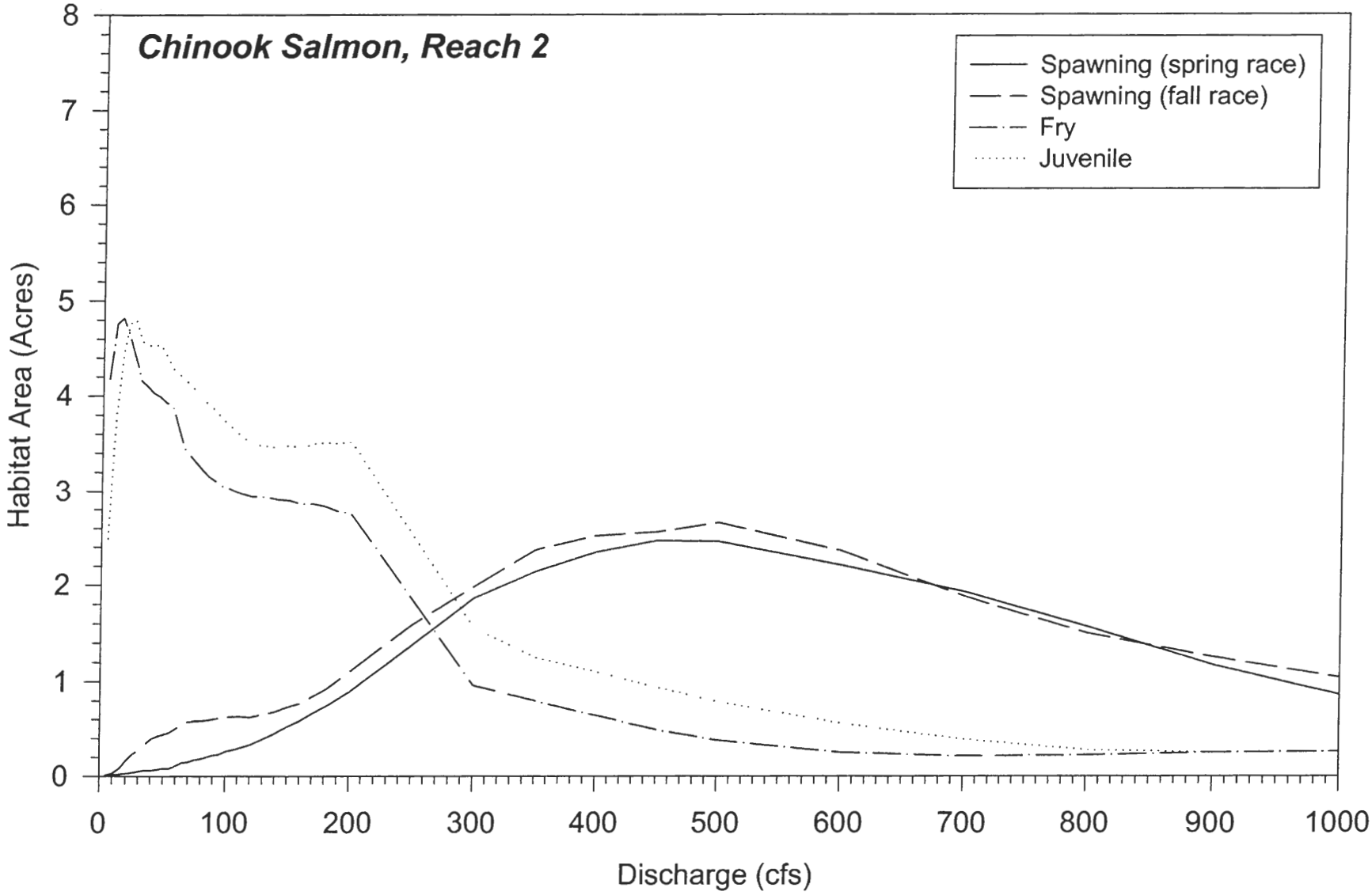

Figure 4-9. Chinook salmon total habitat area (HA) versus discharge relationships for Reach 2, Lostine River, Oregon.

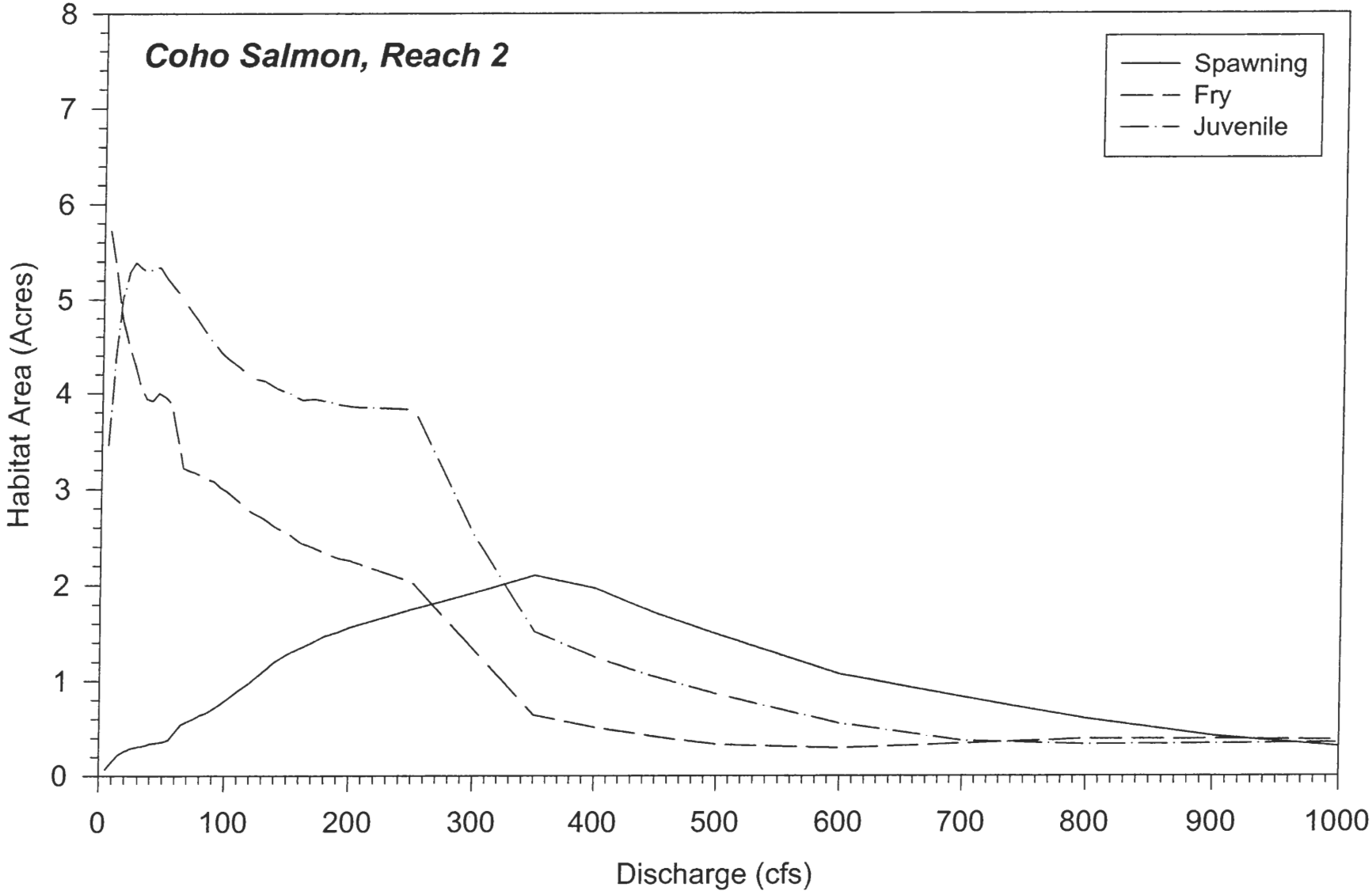

Figure 4-10. Coho salmon total habitat area (HA) versus discharge relationships for Reach 2, Lostine River, Oregon.

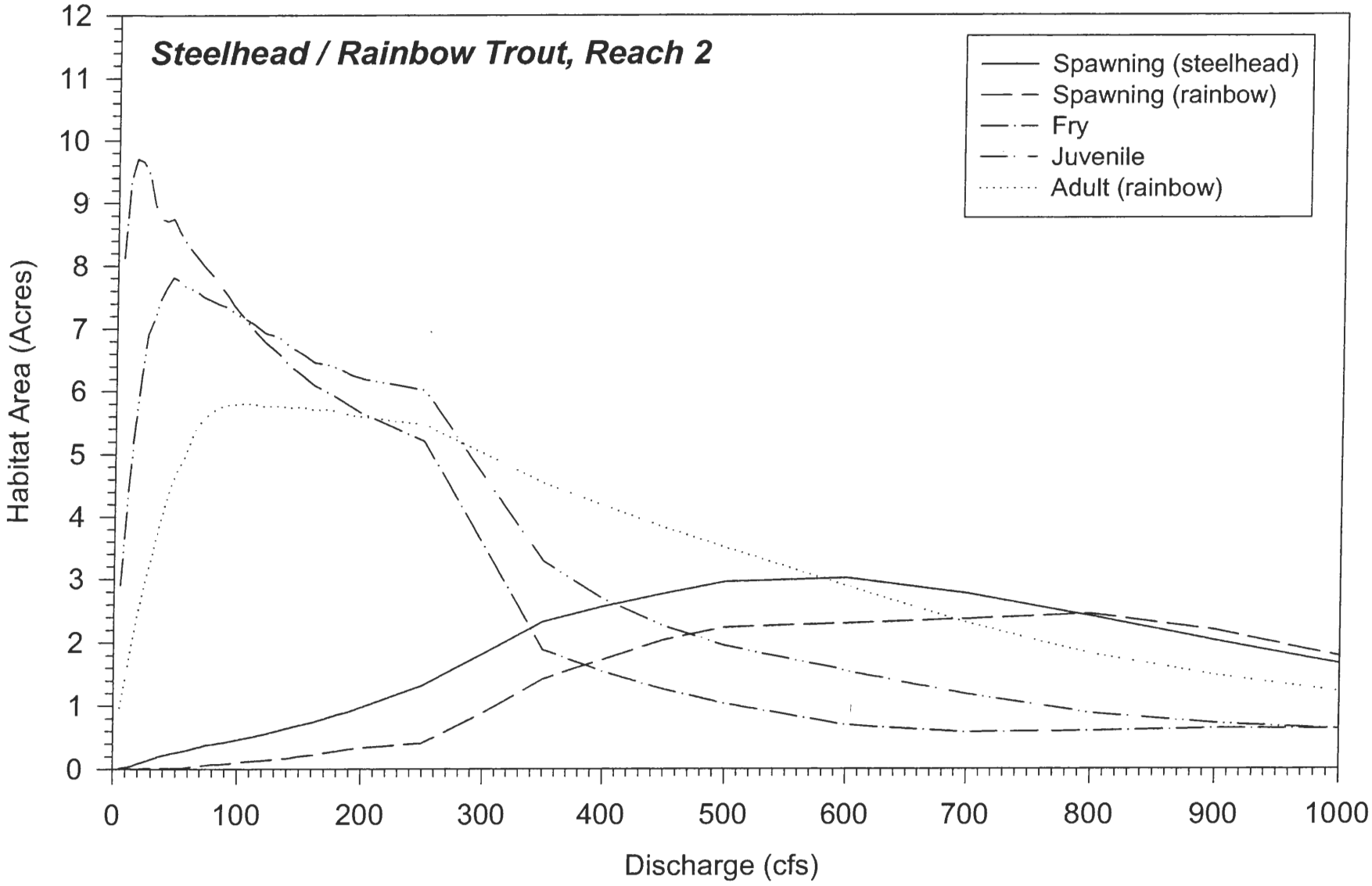

Figure 4-11. Steelhead and rainbow trout total habitat area (HA) versus discharge relationships for Reach 2, Lostine River, Oregon.

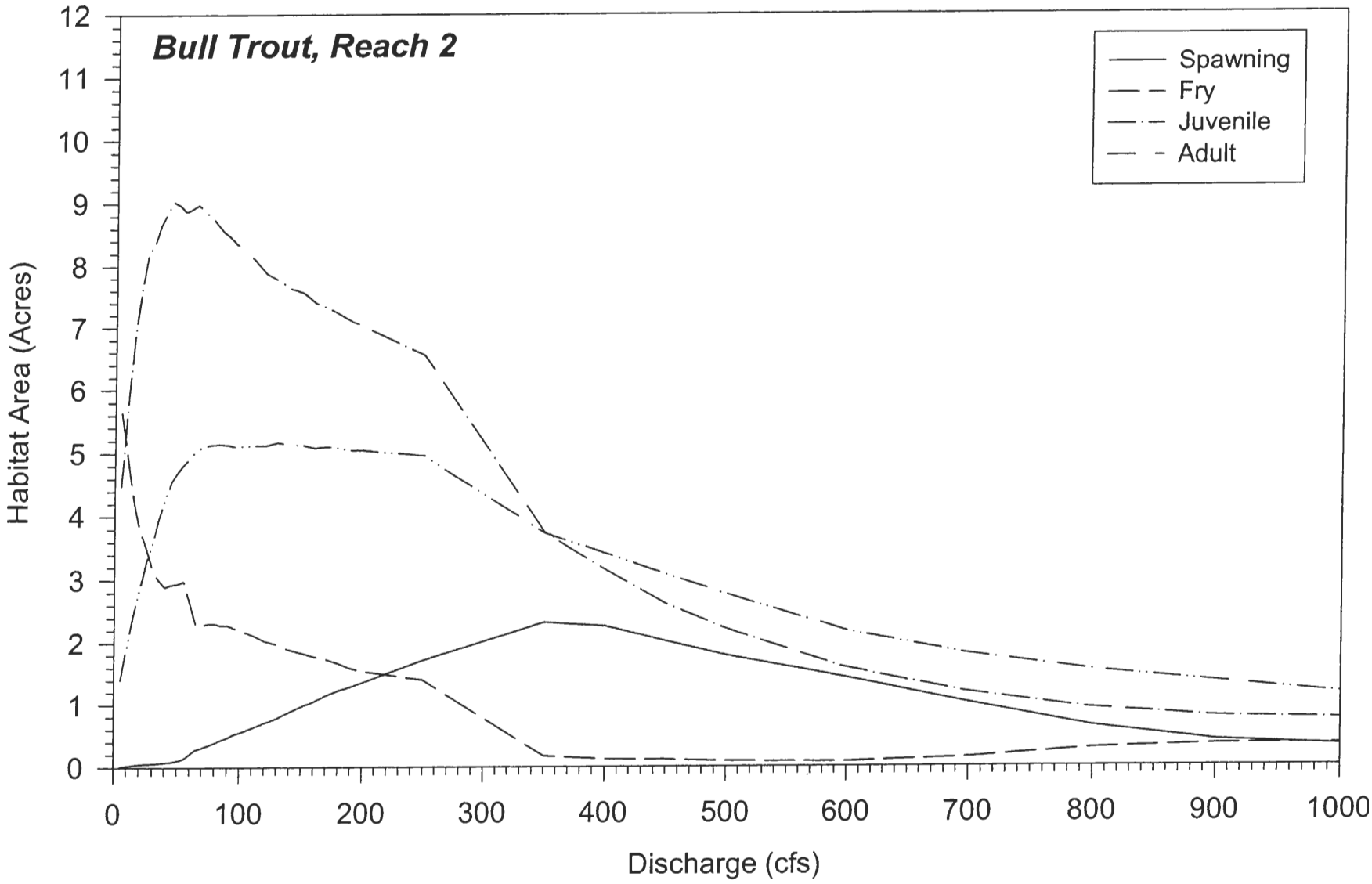

Figure 4-12. Bull trout total habitat area (HA) versus discharge relationships for Reach 2, Lostine River, Oregon.

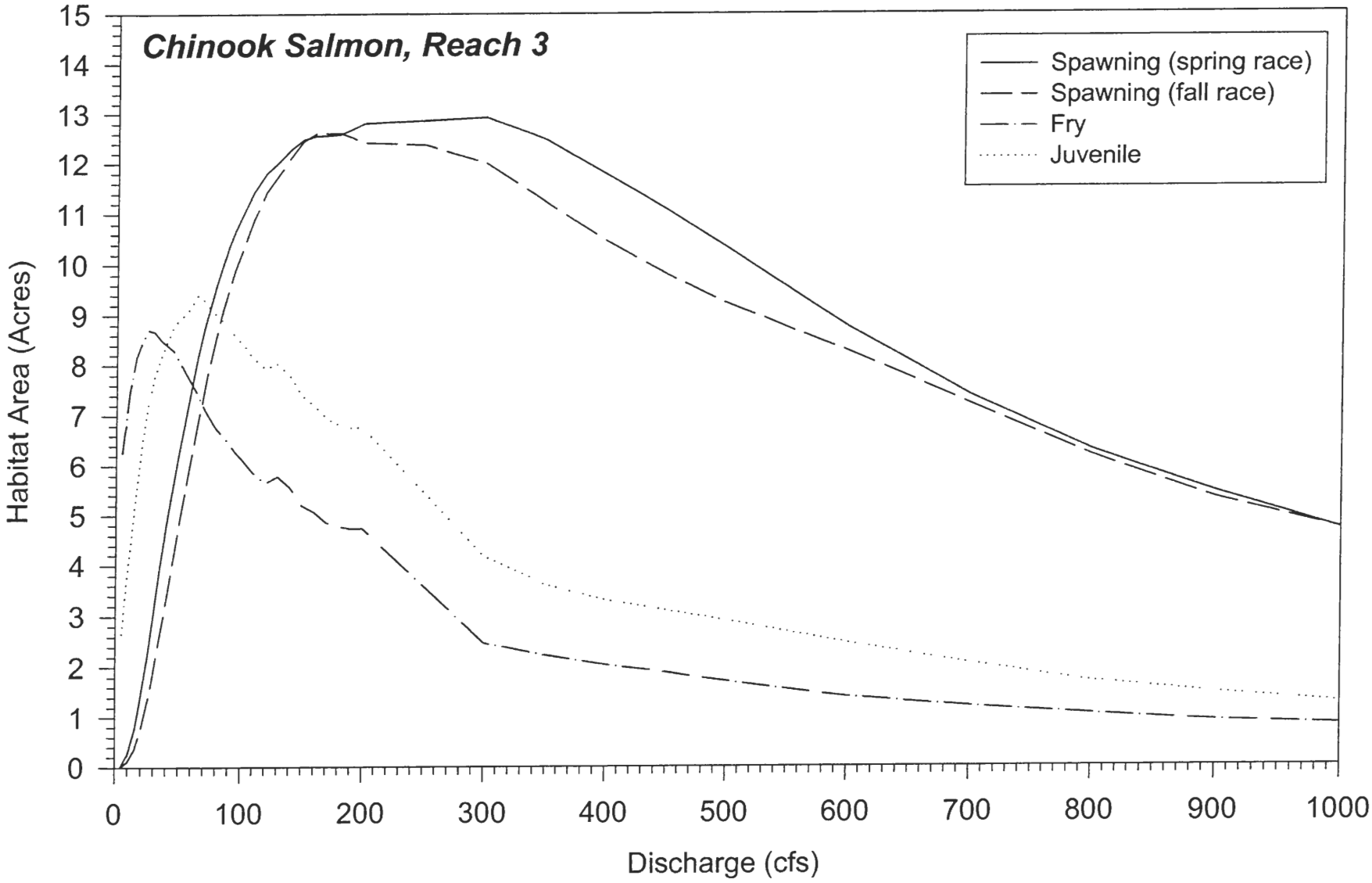

Figure 4-13. Chinook salmon total habitat area (HA) versus discharge relationships for Reach 3, Lostine River, Oregon.

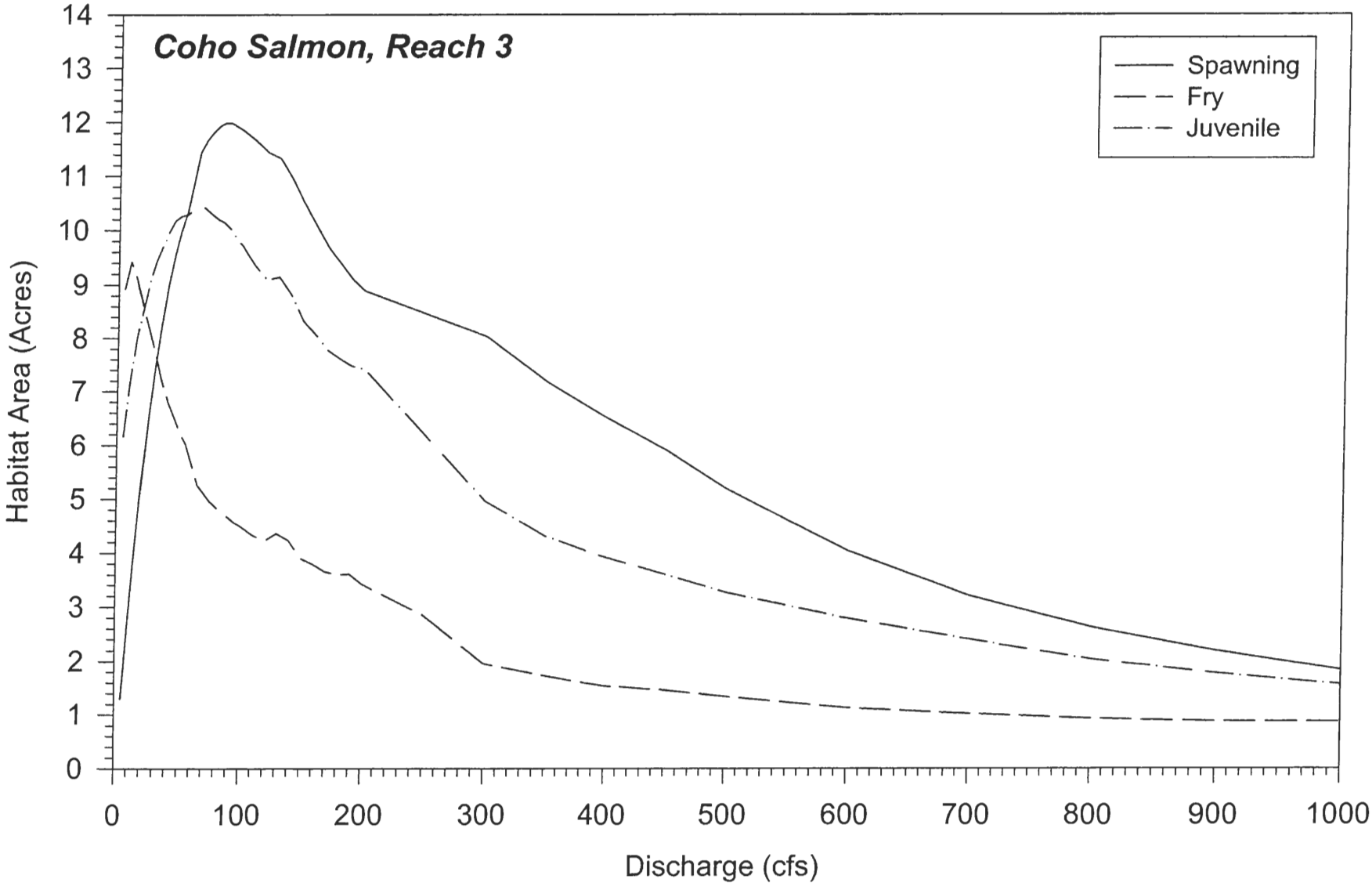

Figure 4-14. Coho salmon total habitat area (HA) versus discharge relationships for Reach 3, Lostine River, Oregon.

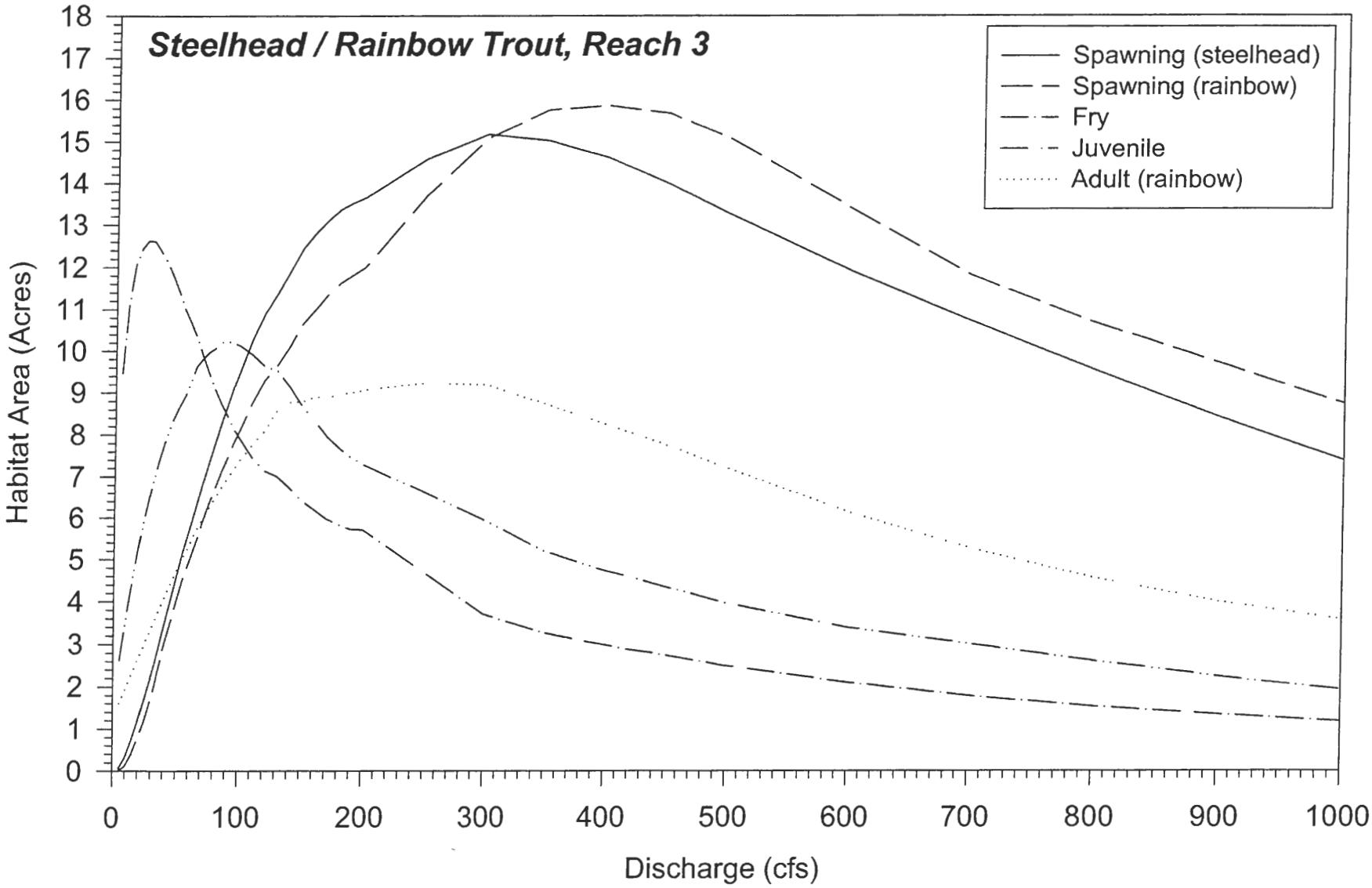

Figure 4-15. Steelhead and rainbow trout total habitat area (HA) versus discharge relationships for Reach 3, Lostine River, Oregon.

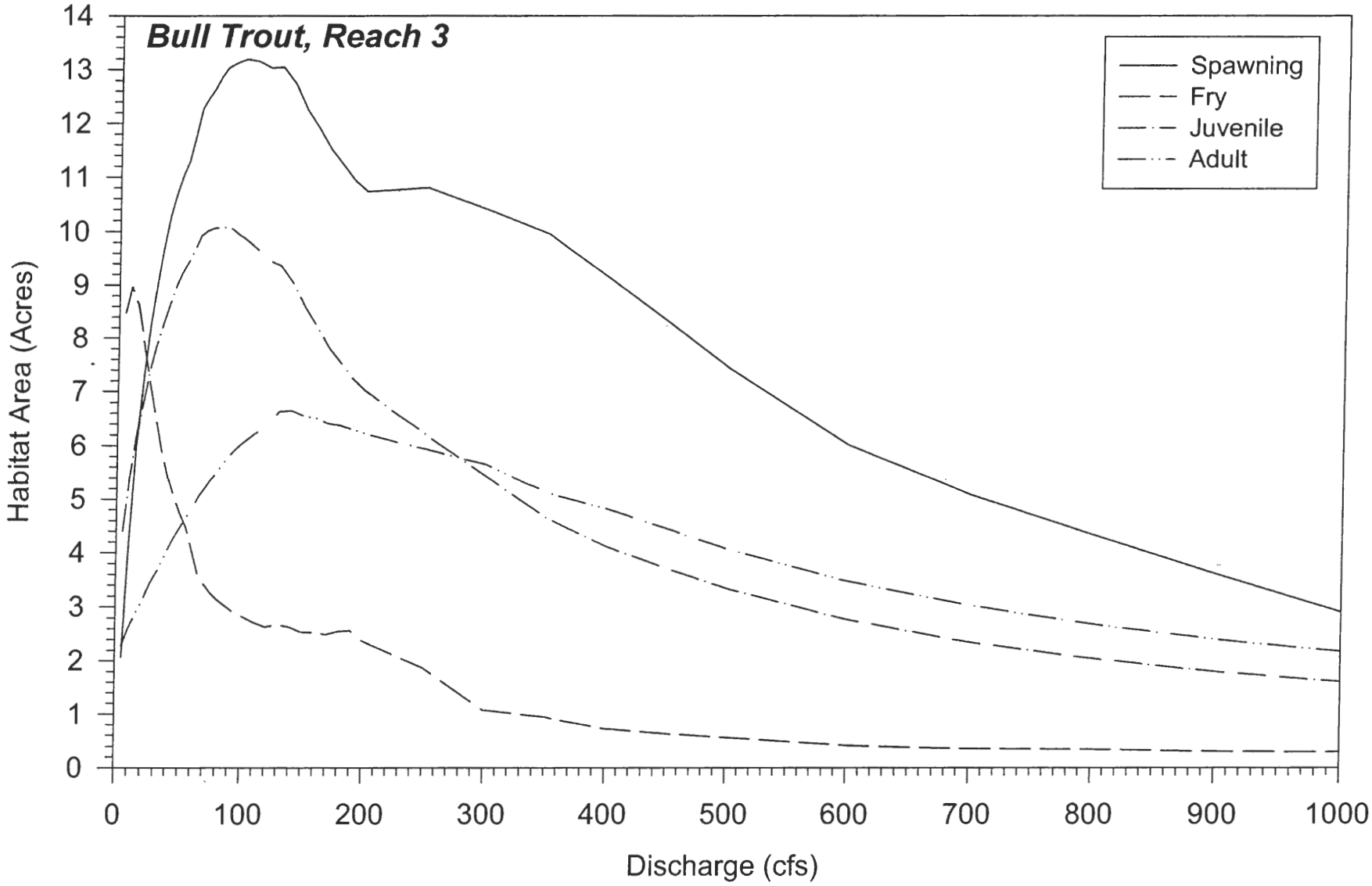

Figure 4-16. Bull trout total habitat area (HA) versus discharge relationships for Reach 3, Lostine River, Oregon.

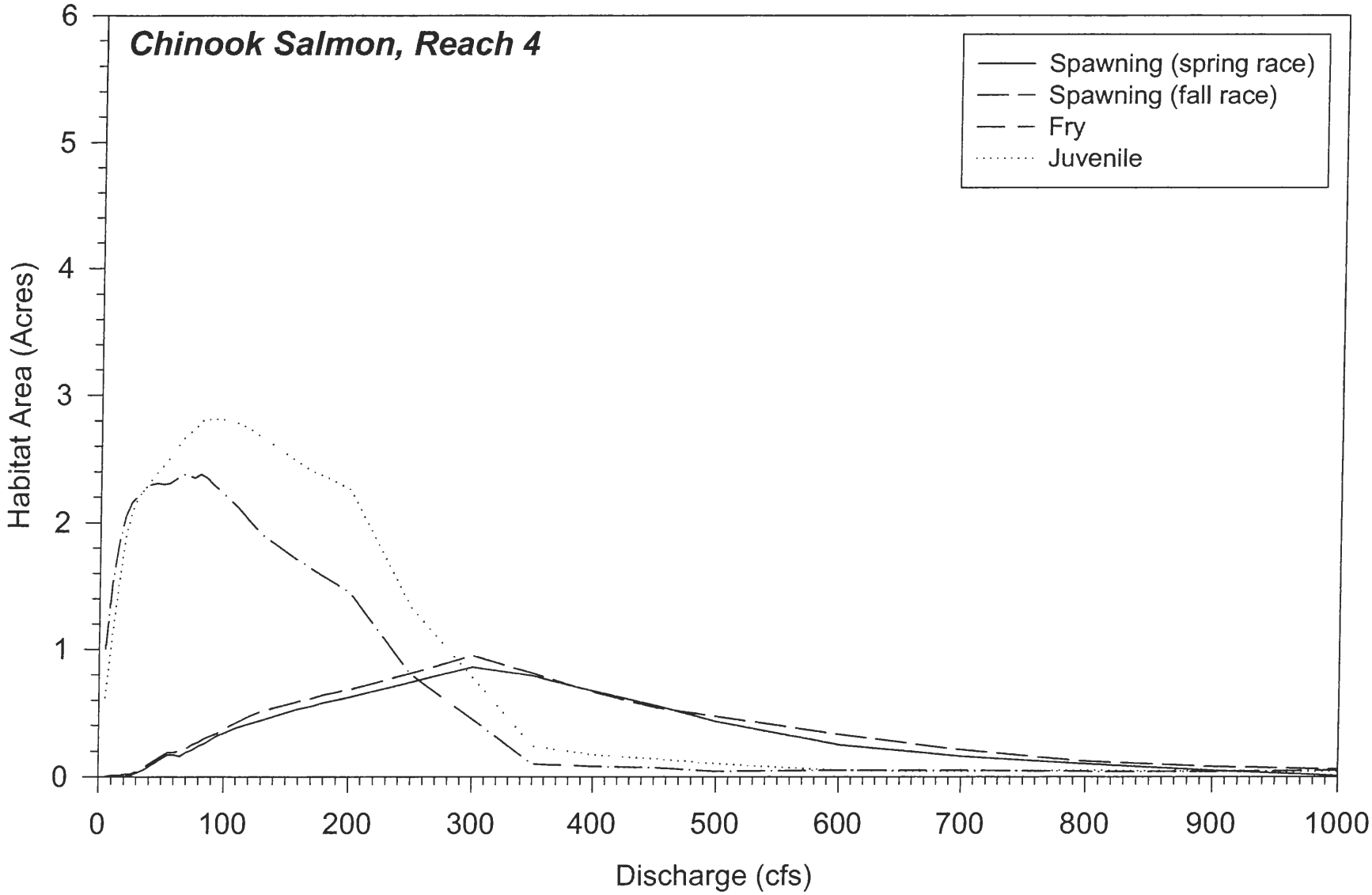

Figure 4-17. Chinook salmon total habitat area (HA) versus discharge relationships for Reach 4, Lostine River, Oregon.

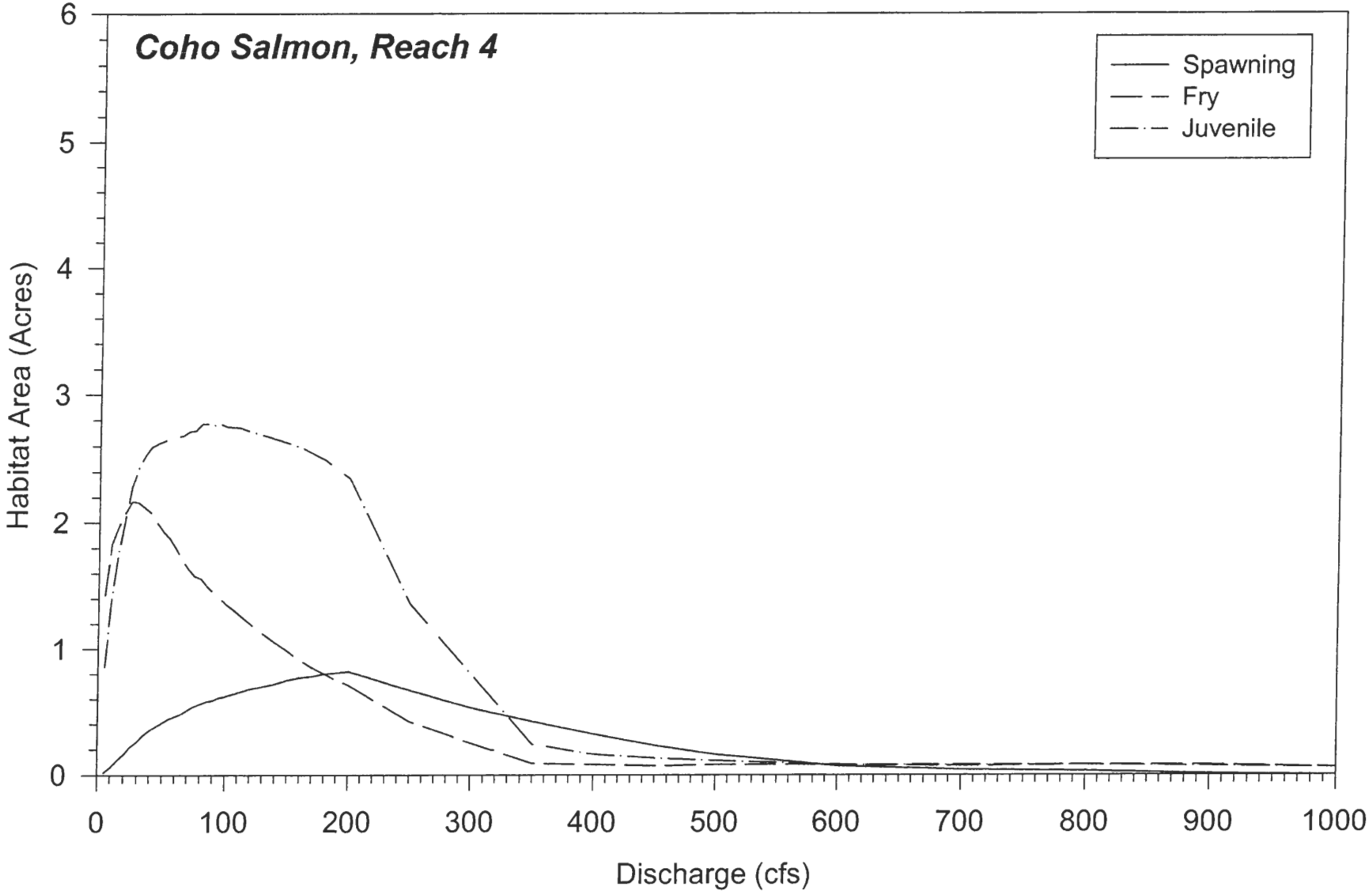

Figure 4-18. Coho salmon total habitat area (HA) versus discharge relationships for Reach 4, Lostine River, Oregon.

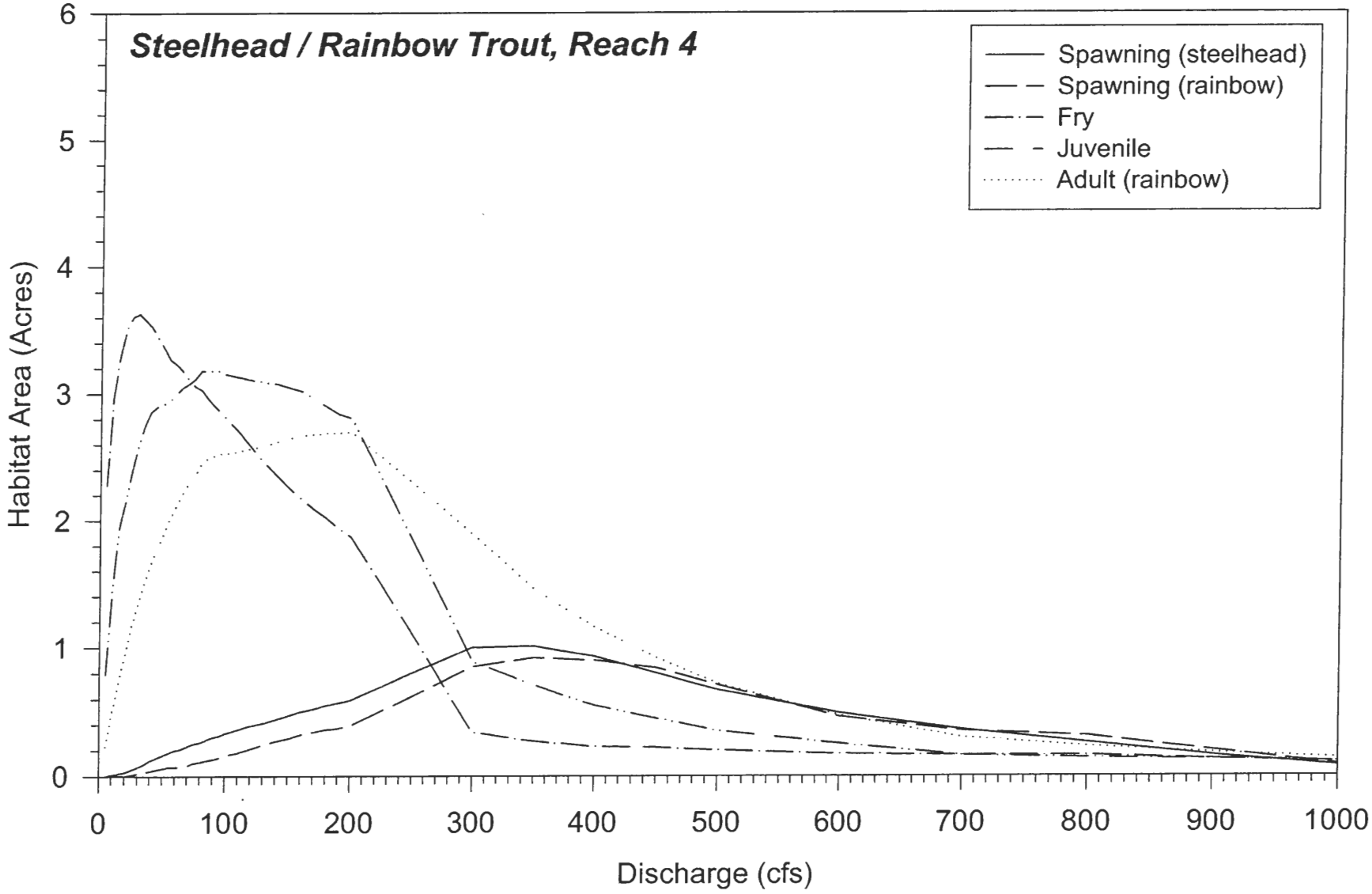

Figure 4-19. Steelhead and rainbow trout total habitat area (HA) versus discharge relationships for Reach 4, Lostine River, Oregon.

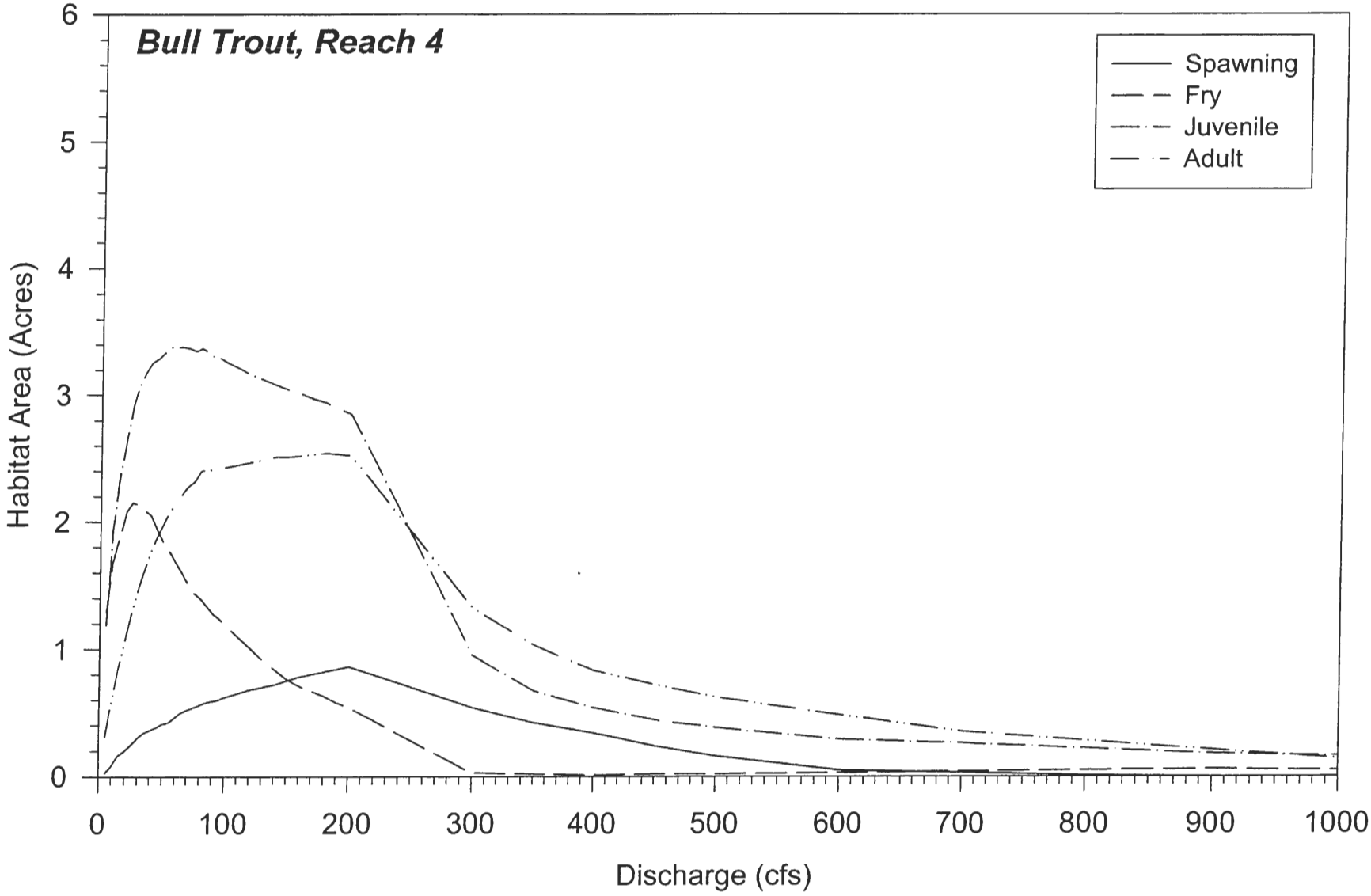

Figure 4-20. Bull trout total habitat area (HA) versus discharge relationships for Reach 4, Lostine River, Oregon.

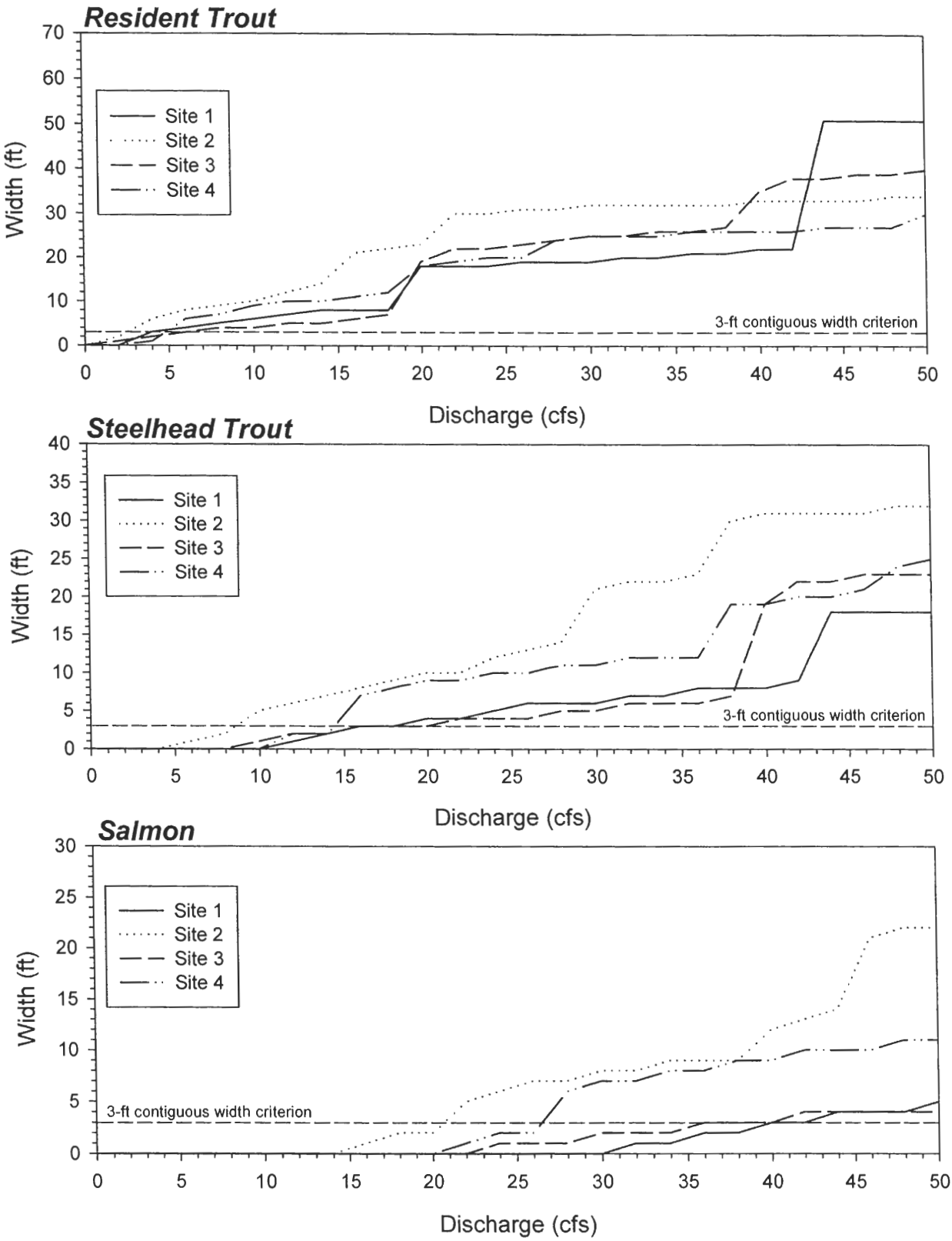

Figure 4-21. Upstream passage versus discharge curves for Reach 1 of the Lostine River, Oregon. Each curve shows the contiguous width of the river cross-section in which depth exceeds the minimum passage criteria of 0.4 ft for resident trout, 0.6 ft for steelhead trout, and 0.8 ft for salmon.

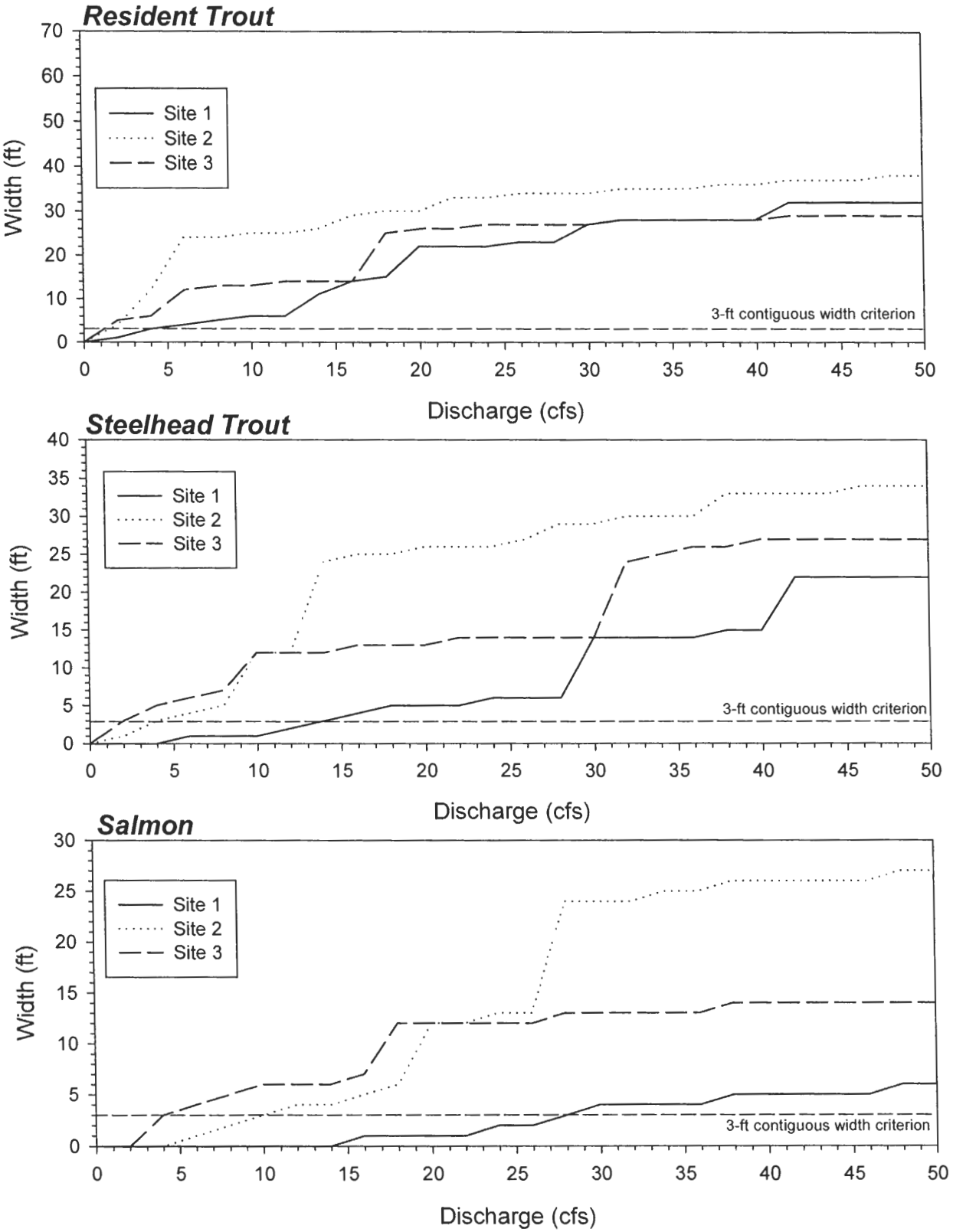

Figure 4-22. Upstream passage versus discharge curves for Reach 2 of the Lostine River, Oregon. Each curve shows the contiguous width of the river cross-section in which depth exceeds the minimum passage criteria of 0.4 ft for resident trout, 0.6 ft for steelhead trout, and 0.8 ft for salmon.

Table 4-1. Summary of dates and discharges for hydraulic measurements obtained in the Lostine River, 1995-1996.

Reach	Site	Low Flow		Medium Flow		High Flow	
		Date	Discharge (cfs)	Date	Discharge (cfs)	Date	Discharge (cfs)
1	1	8/16/95	65	3/5/96	108	6/5/96	925
	2	8/14/95	46	3/6/96	93	6/5/96	901
	3	8/14/95	43	3/6/96	93	6/5/96	894
	4	8/16/95	61	5/8/96	137	6/6/96	819
2	1	8/15/95	52	5/10/96	154	6/5/96	948
	2	8/16/95	64	5/10/96	154	6/5/96	1005
	3	8/16/95	67	5/9/96	150	6/6/96	845
3	1	10/31/95	66	8/17/95	111	6/4/96	960
	2	10/31/95	45	8/17/95	111	6/4/96	1021
	3	10/31/95	51	8/17/95	111	6/4/96	1085
4	1	10/31/95	56	8/18/95	93	6/5/96	976

Table 4-2. **Wetted widths, mean depths, and mean velocities predicted for three flow conditions at Reach 1 transects in the Lostine River, Oregon, by IFG4 hydraulic simulation modeling.**

Site	Transect	Habitat Type	Wetted Width (ft)			Mean Depth (ft)			Mean Velocity (ft/sec)		
			10 cfs	100 cfs	1000 cfs	10 cfs	100 cfs	1000 cfs	10 cfs	100 cfs	1000 cfs
1	1	Riffle/Rapid	21.8	41.9	54.6	0.3	0.8	2.7	1.5	3.0	6.9
	2	Riffle	33.5	54.0	62.6	0.3	0.8	2.6	1.1	2.4	6.1
	3	Run	51.4	56.7	62.8	0.3	0.9	2.4	0.6	2.1	6.7
	4	Pool	28.4	49.3	61.7	1.7	1.6	3.0	0.2	1.3	5.4
		Average:	*33.8*	*50.5*	*60.4*	*0.6*	*1.0*	*2.7*	*0.9*	*2.2*	*6.3*
2	1	Riffle/Run	32.5	41.0	48.9	0.4	1.1	3.0	0.7	2.2	6.9
	2	Pool	17.1	28.1	34.5	1.7	1.9	3.1	0.4	1.9	9.4
	3	Riffle/Rapid	40.7	61.8	67.5	0.4	0.8	1.9	0.7	2.1	7.8
	4	Run	26.1	43.2	52.9	0.5	1.1	2.2	0.8	2.1	8.7
		Average:	*29.1*	*43.5*	*51.0*	*0.7*	*1.2*	*2.5*	*0.6*	*2.1*	*8.2*
3	1	Pool	27.4	33.4	50.5	1.8	2.2	3.0	0.2	1.4	6.6
	2	Riffle/Rapid	37.1	46.4	65.3	0.3	0.9	2.6	0.8	2.3	5.9
	3	Riffle	39.5	54.1	70.3	0.3	0.8	2.4	0.9	2.2	6.0
	4	Run	31.5	51.2	72.6	0.4	0.9	2.2	0.7	2.1	6.4
		Average:	*33.9*	*46.3*	*64.7*	*0.7*	*1.2*	*2.5*	*0.7*	*2.0*	*6.2*
4	1	Riffle/Rapid	25.8	69.3	77.6	0.4	0.7	2.3	1.1	2.1	5.6
	2	Riffle	30.4	57.4	83.9	0.4	0.8	2.0	0.8	2.1	6.0
	3	Run	44.4	71.1	78.5	0.3	0.7	2.0	0.8	2.1	6.3
	4	Pool	32.6	47.3	96.1	0.4	1.1	2.1	0.7	2.0	5.7
		Average:	*33.3*	*61.3*	*84.0*	*0.4*	*0.8*	*2.1*	*0.9*	*2.0*	*5.9*

Table 4-3. Wetted widths, mean depths, and mean velocities predicted for three flow conditions at Reach 2 transects in the Lostine River, Oregon, by IFG4 hydraulic simulation modeling.

Site	Transect	Habitat Type	Wetted Width (ft)			Mean Depth (ft)			Mean Velocity (ft/sec)		
			10 cfs	100 cfs	1000 cfs	10 cfs	100 cfs	1000 cfs	10 cfs	100 cfs	1000 cfs
1	1	Pool	19.6	35.6	71.2	0.7	1.2	2.5	0.8	2.3	5.6
	2	Riffle/Rapid	24.0	58.4	63.3	0.5	0.9	2.6	0.9	1.9	6.1
	3	Riffle/Run	31.4	50.4	61.1	0.7	0.8	2.4	0.5	2.4	6.9
	4	Run	31.8	48.8	55.9	0.3	0.9	2.5	0.9	2.4	7.2
		Average:	*26.7*	*48.3*	*62.9*	*0.5*	*1.0*	*2.5*	*0.8*	*2.3*	*6.4*
2	1	Riffle/Run	27.9	41.6	69.9	0.7	0.9	2.3	0.6	2.6	6.3
	2	Run	30.9	38.4	50.8	0.6	1.4	3.6	0.6	1.8	5.5
	3	Riffle/Rapid	34.0	42.0	54.1	0.6	1.0	3.7	0.5	2.4	5.5
	4	Riffle	35.5	45.0	48.7	0.5	1.2	2.8	0.5	1.9	7.4
		Average:	*32.1*	*41.8*	*55.9*	*0.6*	*1.1*	*3.1*	*0.6*	*2.2*	*6.1*
3	1	Pool	30.8	38.2	51.0	1.0	1.4	3.1	0.3	1.9	6.3
	2	Run	25.9	50.5	70.7	0.8	1.2	2.7	0.5	1.6	5.3
	3	Riffle	33.7	44.1	54.1	0.8	1.1	2.6	0.4	2.0	7.1
	4	Riffle/Rapid	33.4	48.5	58.6	0.5	1.1	2.8	0.6	1.8	6.0
		Average:	*31.0*	*45.3*	*58.6*	*0.8*	*1.2*	*2.8*	*0.5*	*1.8*	*6.2*

Table 4-4. Wetted widths, mean depths, and mean velocities predicted for three flow conditions at Reach 3 transects in the Lostine River, Oregon, by IFG4 hydraulic simulation modeling.

Site	Transect	Habitat Type	Wetted Width (ft)			Mean Depth (ft)			Mean Velocity (ft/sec)		
			10 cfs	100 cfs	1000 cfs	10 cfs	100 cfs	1000 cfs	10 cfs	100 cfs	1000 cfs
1	1	Riffle	48.6	78.5	100.4	0.4	0.9	2.1	0.5	1.4	4.8
	2	Run	62.3	71.2	86.7	0.7	1.0	2.4	0.2	1.4	4.8
	3	Pool	49.6	51.7	61.0	2.2	2.5	3.8	0.1	0.8	4.3
	4	Riffle/Run	44.2	54.3	91.0	0.4	1.0	2.2	0.5	1.8	5.0
		Average:	*51.2*	*63.9*	*84.8*	*0.9*	*1.4*	*2.6*	*0.3*	*1.3*	*4.7*
2	1	Riffle	60.6	84.3	112.3	0.2	0.6	2.0	0.9	2.0	4.4
	2	Run	66.5	71.1	95.2	0.4	0.8	2.2	0.2	1.8	4.8
	3	Run/Pool	62.1	65.8	92.3	1.0	1.4	2.5	0.2	1.1	4.3
	4	Pool	58.6	61.5	74.0	2.7	3.1	4.4	0.1	0.5	3.1
		Average:	*62.0*	*70.7*	*93.5*	*1.1*	*1.5*	*2.8*	*0.3*	*1.3*	*4.2*
3	1	Riffle	47.4	68.7	129.2	0.4	1.0	1.9	0.5	1.5	4.1
	2	Run	42.4	81.7	150.4	0.3	0.7	1.9	0.7	1.7	3.5
	3	Run	49.7	63.0	134.0	0.7	1.3	2.1	0.3	1.2	3.5
	4	Pool/Run	38.6	79.4	113.9	0.6	0.9	2.2	0.3	1.5	4.1
		Average:	*44.5*	*73.2*	*131.9*	*0.5*	*1.0*	*2.0*	*0.4*	*1.5*	*3.8*

Table 4-5. Wetted widths, mean depths, and mean velocities predicted for three flow conditions at Reach 4 transects in the Lostine River, Oregon, by IFG4 hydraulic simulation modeling.

Site	Transect	Habitat Type	Wetted Width (ft)			Mean Depth (ft)			Mean Velocity (ft/sec)		
			10 cfs	100 cfs	1000 cfs	10 cfs	100 cfs	1000 cfs	10 cfs	100 cfs	1000 cfs
1	1	Run/Riffle	29.5	39.0	41.5	0.6	1.6	3.6	0.6	1.5	6.8
	2	Pool	18.9	32.5	37.2	1.4	1.8	3.5	0.4	1.7	7.8
	3	Riffle/Rapid	29.8	43.9	47.2	0.6	1.2	2.6	0.4	2.0	8.3
	4	Riffle/Rapid	30.9	43.1	59.6	0.6	1.3	2.6	0.5	1.8	6.2
		Average:	*27.3*	*39.6*	*46.4*	*0.8*	*1.5*	*3.0*	*0.5*	*1.7*	*7.2*

Table 4-6. Habitat type and site weighting values employed in Lostine River, Oregon, PHABSIM habitat simulations. Values based upon corrected ODFW (1991) habitat survey results.

Reach	Site	Representative Length (m)			
		Pool	Riffle/Run	Rapid/Cascade	Total
1	1	66	2,318	113	2,496
	2	97	1,136	119	1,352
	3	330	1,132	102	1,564
	4	159	2,245	298	2,702
Reach Totals:		*652*	*6,831*	*632*	*8,114*
2	1	74	2,413	0	2,487
	2	144	1,079	7	1,230
	3	306	2,059	3	2,368
Reach Totals:		*524*	*5,552*	*9*	*6,086*
3	1	483	2,104	89	2,677
	2	278	905	0	1,183
	3	245	1,060	0	1,305
Reach Totals:		*1,007*	*4,069*	*89*	*5,164*
4	1	26	748	1,164	1,939
Reach Totals:		*26*	*748*	*1,164*	*1,939*

Table 4-7. Habitat type and site weighting percentages employed in Lostine River, Oregon, PHABSIM habitat simulations. Values based upon corrected ODFW (1991) habitat survey results.

Reach	Site	Representative Length (%)			
		Pool	Riffle/Run	Rapid/Cascade	Percent of Reach
1	1	2.7%	92.8%	4.5%	30.8%
	2	7.1%	84.0%	8.8%	16.7%
	3	21.1%	72.4%	6.5%	19.3%
	4	5.9%	83.1%	11.0%	33.3%
Reach Average:		*8.0%*	*84.2%*	*7.8%*	
2	1	3.0%	97.0%	0.0%	40.9%
	2	11.7%	87.7%	0.5%	20.2%
	3	12.9%	87.0%	0.1%	38.9%
Reach Average:		*12.9%*	*87.0%*	*0.1%*	
3	1	18.1%	78.6%	3.3%	51.8%
	2	23.5%	76.5%	0.0%	22.9%
	3	18.8%	81.2%	0.0%	25.3%
Reach Average:		*19.5%*	*78.8%*	*1.7%*	
4	1	1.4%	38.6%	60.0%	100.0%
Reach Average:		*1.4%*	*38.6%*	*60.0%*	

Table 4-8. Summary of discharge values (as determined from PHABSIM analysis) which provide maximum total habitat area (HA) for target fish species and life stages in the Lostine River, Oregon.

Species	Life Stage	Discharge (cfs)			
		Reach 1	Reach 2	Reach 3	Reach 4
Chinook Salmon	Spawning (spring race)	120	450	300	300
	Spawning (fall race)	120	500	180	300
	Fry	50	15	25	65
	Juvenile	55	25	65	95
Coho Salmon	Spawning	65	350	90	200
	Fry	50	5	10	25
	Juvenile	50	25	70	80
Steelhead and Rainbow Trout	Spawning (steelhead trout)	140	600	300	350
	Spawning (rainbow trout)	350	800	400	350
	Fry	25	15	25	30
	Juvenile	65	45	90	80
	Adult (rainbow trout)	120	100	300	200
Bull Trout	Spawning	65	350	100	200
	Fry	15	5	10	25
	Juvenile	65	45	85	55
	Adult	90	130	140	180

Table 4-9. Summary of discharge values (as determined from PHABSIM analysis) which provide 50 percent of maximum total habitat area (HA) for target fish species and life stages in the Lostine River, Oregon.

Species	Life Stage	Discharge (cfs)			
		Reach 1	Reach 2	Reach 3	Reach 4
Chinook Salmon	Spawning (spring race)	45	250	55	130
	Spawning (fall race)	55	250	65	120
	Fry	5	5	5	10
	Juvenile	15	5	15	15
Coho Salmon	Spawning	20	13 0	25	50
	Fry	5	5	5	5
	Juvenile	10	5	5	10
Steelhead and Rainbow Trout	Spawning (steelhead trout)	60	300	80	170
	Spawning (rainbow trout)	80	350	95	250
	Fry	5	5	5	5
	Juvenile	25	10	20	15
	Adult (rainbow trout)	45	25	50	30
Bull Trout	Spawning	20	170	20	55
	Fry	5	5	5	5
	Juvenile	20	5	10	10
	Adult	35	20	25	25

5. DISCUSSION

The HA versus flow relationships varied considerably among the four study reaches in the Lostine River. This variability can be attributed to differences in geomorphology, channel geometry, and substrate composition among these four reaches.

5.1 RELATIONSHIPS BETWEEN HABITAT AND GEOMORPHOLOGY

Reach 1, the most downstream of the four study reaches, was located in a wide agricultural valley and possessed a moderate gradient of 1.1 percent. Due to its moderate gradient and lack of confinement by adjacent terrain, the river channel in Reach 1 was considerably wider compared to that in Reach 2. Instream flow requirements were consequently greater for all species and life stages except spawning in Reach 1 than in Reach 2. More water is needed to provide suitable depths and velocities for fish in Reach 1 because of its greater width.

Because of its lower gradient and greater width, substrates suitable for chinook salmon, coho salmon, and steelhead spawning (i.e., gravels and small cobbles) are far more abundant in Reach 1 than in Reach 2. For this reason, Reach 1 provides much more spawning habitat than Reach 2. In contrast, Reach 2 is dominated by larger cobbles and small boulders due to its higher gradient (1.7 percent) and greater confinement by adjacent hillslopes. Reach 2 is also more channelized than Reach 1 which further contributes to the lack of smaller substrates (i.e., gravels). Gravels in Reach 2 are relatively scarce and are in most cased located along the margins of the stream channel. The instream flows needed to provide maximum HA values for spawning were much higher in Reach 2 than in the other three study reaches for this reason. Spawning gravel areas located along the margins of the channel, such as those observed in Reach 2, usually produce very few successful redds because these areas are so prone to dewatering during low flow periods following spawning. However, Reach 2 provides better habitat conditions then Reach 1 for juvenile steelhead and rainbow trout, as well as adult rainbow, because this reach is dominated by larger cobbles and boulders. The coarse substrates present in many sections of Reach 2 provide highly suitable "pocket water" habitat for these species and life stages (this type of habitat provides excellent velocity refuge areas, feeding zones, and cover for these fish). The best habitat for juvenile steelhead/rainbow trout and adult rainbow trout was located in the upper reaches of Reach 2, which consisted mainly of natural channel (i.e., unchannelized).

The river channel within Reach 3 was considerably different than that of the preceding two reaches. Reach 3 was located in a broad mountain foothill valley, and had a much lower gradient (0.7 percent) than the other reaches. The river channel in Reach 3 was significantly wider and more sinuous than the other study reaches. Because of these morphological characteristics, this reach contained substantially greater concentrations of spawning gravels than the other three reaches. Because of its proximity at the base of the Wallowa Mountains, Reach 3 serves as a natural catch area for bedload originating from the upper Lostine River. Spawning habitat in Reach 3 can be considered to be excellent. As mentioned earlier, the highest density of spring chinook salmon spawning redds have been measured in this reach during spawning surveys conducted in the Lostine River by ODFW and tribal biologists. The low gradient and meandering nature of the river channel in Reach 3 results in a much higher frequency of deep pools than that observed in the other three study reaches. Pools in this reach were often associated with woody debris. In contrast, deep pools in Reach 1 and Reach 4 are typically associated with bedrock outcroppings, while those in Reach 2 are associated with large boulders. Unfortunately, pool forming features are relatively rare in Reaches 1, 2, and 4. The relative abundance of deep pools in Reach 3 provides important holding habitat for adult chinook salmon and steelhead (especially important because spring chinook spawning areas are located within this reach), as well as good habitat for older age classes of juvenile steelhead/rainbow trout and adult rainbow trout. Most of the juvenile steelhead/rainbow trout parr and adult rainbow trout observed during snorkel surveys conducted in Reach 3 during low flow conditions were located in the deep pools found throughout this reach.

Reach 4 was the most confined of the reaches studied due to its location within a steep mountain canyon, and as such had the narrowest channel width. It also had the highest gradient (4.2 percent) of the four study reaches. Due to the narrow and steep nature of the river channel, Reach 4 possessed the swiftest currents and largest substrate sizes (small to large boulders). Like Reach 2, spawning gravels in this reach were scarce and located mostly along the stream margins. However, habitat conditions for juvenile and adult rainbow and bull trout could be considered to be excellent in this reach due to the abundance of deep "pocket water' and boulder cover. Because Reach 4 is located within a densely forested canyon immediately below headwater streams, water temperatures in this reach would be expected to be much cooler than those occurring in the lower reaches. The channel and water temperature characteristics of this reach would be expected to provide the best habitat of the four reaches for juvenile and adult bull trout.

5.2 RELATIONSHIPS BETWEEN HABITAT AND FLOW

Maximum habitat conditions for spawning spring and early fall chinook salmon were provided by flows of 120 cfs in Reach 1, but ranged between 180 and 500 cfs in the other three reaches. Similar patterns in the habitat versus flow relationships were observed for coho salmon, steelhead trout, rainbow trout, and bull trout spawning. Higher flows for spawning fish are required in Reaches 2 and 4 because most of the spawning-sized gravels in these reaches are located along the channel margins. Both of these reaches possessed channels dominated by large-cobble and boulder substrates; gravels and small cobbles suitable for spawning were limited to channel margin areas at most transects. The flows that provided maximum HA for rainbow trout and bull trout in Reaches 2 and 4 were equal to or higher than those for chinook salmon, coho salmon, and steelhead trout. This was a result of the preference of spawning rainbow trout and bull trout for smaller substrates, which were restricted to the channel margins in the two reaches. Maximum HA values were also provided at flows ranging from 90 to 300 cfs for spawning fish in Reach 3, even though gravels were abundant throughout the channel in this reach. In this case, higher flow requirements resulted from the wide geometry of the Reach 3 river channel compared to the other reaches. The depths and velocities most suitable for spawning were provided by a higher range of flows in Reach 3 compared to the other three reaches.

Fry required the lowest flows of all the life stages evaluated in the Lostine River. This is a consequence of the preference of fry for low velocities and shallow depths. Maximum habitat values were provided by flows between 15 and 65 cfs for chinook salmon fry, 5 and 50 cfs for coho salmon fry, 15 and 30 cfs for steelhead and rainbow trout fry, and 5 and 25 cfs for bull trout fry. The lowest flows providing maximum habitat conditions for fry were observed in Reach 2, while the highest flows providing maximum habitat conditions for fry were observed in Reach 4.

The flows which provided the maximum attainable habitat for juvenile fish were relatively similar among the different species evaluated. Maximum attainable habitat for juvenile fish was provided by flows between 55 and 65 cfs in Reach 1, between 25 and 45 cfs in Reach 2, between 65 and 95 cfs in Reach 3, and between 55 and 95 cfs in Reach 4. This is likely a consequence of the similar depth and velocity ranges preferred by juvenile fish compared to other life stages.

Flows providing the maximum attainable habitat were considerably higher for rainbow and bull trout adults when compared to that for juveniles. Maximum HA values for rainbow trout adults were obtained at flows ranging from 100 cfs in Reach 1 to 300 cfs in Reach 3. For bull trout,

maximum HA values were obtained at flows between 90 cfs in Reach 1 to 180 cfs in Reach 4. Higher flows provided greater amounts of habitat for these adult fish because of their preference and tolerance for greater depths and faster velocities.

5.3 UPSTREAM PASSAGE CONCERNS

Upstream passage is one of the most important limiting factors to populations of spring chinook and early fall chinook salmon in the Lostine River drainage. Passage of these fish is hindered or blocked by shallow water depths during low flow periods in August and September, especially during periods when water withdrawals for irrigation are greatest. Low flows likely affected coho salmon in the Lostine River prior to their extinction in the Snake River basin. Coho historically immigrated to spawning areas in the Lostine River from September through October, a period when the lowest natural flows of the year occur in this river.

Passage success was analyzed by examining depth versus flow relationships within the shallowest areas (typically riffles) measured within each reach. Based upon this analysis, a flow of 40 cfs was identified as the minimum required to allow for successful upstream passage of spring and early fall chinook salmon through the lower reaches of the river. The same minimum flow requirement for passage would be required for coho salmon, if reintroduced to the subbasin, to gain access to historic spawning areas located in the Lostine River. Shallow riffles within a channelized section of Reach 1 were found to present the greatest potential barriers to upstream passage during low flow periods. Improved passage of fish can best be achieved by providing higher flows in these reaches during the irrigation season.

Low flow conditions in the lower Lostine River potentially hinder the upstream passage of fluvial bull trout from the Wallowa River into spawning and rearing areas located in the upper reaches of the Lostine River. The migration period of fluvial bull trout typically occurs during the summer and early fall prior to the September and October spawning period of this species; flows in the river are lowest during these months. Bull trout migration is probably also hindered by elevated water temperatures which result from low flow conditions.

Upstream passage is not a problem for steelhead trout, since the peak migration period of spawning steelhead is during periods of the year when flows in the Lostine River are well above the flow required for passage (i.e., 16 cfs). Flows during the peak spawning period of steelhead trout (March through April) typically exceed 100cfs.

5.4 IMPACTS OF CURRENT HABITAT CONDITIONS ON FISH RESOURCES

A number of non-flow and flow related habitat problems are present in the Lostine River which impact populations of anadromous and resident fish. Non-flow related impacts include: 1) channelization and resulting simplification of fish habitat; 2) bank erosion and braiding of the river channel; 3) structural modifications of the channel which result in passage barriers (e.g., irrigation diversion structures); 4) sedimentation caused by forest and agricultural land management activities, as well as by natural disturbances such as fire and landslides; and 5) elevated nutrient loads and subsequent eutrophication due to agricultural practices. Flow related impacts include: 1) degradation and partial dewatering of habitat required by fry, juvenile, and adult fish; 2) elevated water temperatures resulting from low flow condition; 3) blockage of upstream passage of anadromous fish and fluvial bull trout due to insufficient depths; 4) dewatering of redds located along the margins of the stream channel; and 5) degradation and dewatering of invertebrate habitat, which results in reduced food availability for fish.

Non-flow related impacts are most evident in the lower two reaches of the Lostine River. Many sections of Reaches 1 and 2 are channelized, with levees present along one or both banks of the river. As a result of channelization, the length of stream channel contributed by pools is low relative to that observed in the upper reaches of the river. Deep pools provide important holding habitat for adult anadromous fish migrating through this river prior to spawning. Pools also provide important rearing habitat for older age-classes of juvenile anadromous and resident fish, as well as adult resident fish. The simplification of habitat conditions by channelization (e.g., dominance of long and uniform riffle and run habitat types, scarcity of deep pools and woody debris accumulations, lack of overhanging banks) substantially reduces the value of the lower reaches of this river to anadromous and resident fish production.

Channel erosion and subsequent braiding of the stream channel are also evident in sections of Reach 1 and Reach 3. This problem appears to be directly related to prior management activities within or adjacent to the river channel, including the construction of irrigation ditches and gravel mining. Mechanical disturbance to the banks by large equipment is evident in braided sections of Reach 1. Gravel mining in Reach 3 resulted in extensive bank erosion and braiding of sections of the river immediately downstream of the extraction area (note: these operations were discontinued several years ago). Bank erosion and channel braiding result in substantially degraded habitat conditions for juvenile, adult, and spawning fish.

Sedimentation problems were evident in sections of Reach 1 and Reach 3; particularly in run and pool habitat types. Sources of sediments in Reach 1 include inputs from adjacent agricultural lands, as well as inputs from upstream sources. The probable source of sediments in Reach 3 are natural disturbances including landslides and fires in the upper watershed (most of the upper watershed is within the boundaries of the Wallowa-Whitman National Forest). Sedimentation problems were perceived to be low in Reaches 2 and 4; the higher channel gradients and swifter water velocities present in these reaches likely minimize sediment accumulations. Sediment accumulations can degrade spawning habitat by reducing the survival of salmonid eggs and embryos in gravels, and can degrade rearing habitat by filling in the spaces between coarse substrates which provide important summer rearing and winter refuge habitat to juvenile fish.

Impacts caused by low flow conditions are generally present in the lower reaches of the Lostine River between July and January, with the greatest impacts occurring in August and September when peak withdrawals of water for irrigation occur in conjunction with the lowest natural flows of the year. Lows flows occurring after October are usually a result of freezing conditions and precipitation in the form of snowfall within the higher elevations of the watershed. Low flow impacts to fish are greatest in Reaches 1 and 2 of the Lostine River, a result of the numerous irrigation diversions present in these reaches. As mentioned earlier in this report, effects of diversions on flows in the upper two reaches of the river are very minor. The impacts of low flow conditions present in Reaches 1 and 2 vary according to the species and life stage of fish.

5.4.1 Spring and Early Fall Chinook Salmon

Populations of spring and early fall chinook salmon in the Lostine River are impacted by a number of flow and non-flow related factors. Low flows provide a problem to the upstream passage of these fish during August and September. Spring chinook salmon migrating to the prime spawning areas in the river (i.e., Reach 3) prior to August are probably not impeded by low flow barriers, since 90 percent exceedance flows (i.e., baseflows) in the river from May through July exceed 90 cfs. Flows during these months are substantially higher than the 40 cfs predicted to block upstream migration of these fish. However, natural flows during August and September can reach levels as low as 26 cfs (90 percent exceedance flow), and, after withdrawals by irrigation diversions, flows in Reaches 1 and 2 can be reduced below 10 cfs. The low flow conditions in these two reaches during August and September are well below the value predicted to block migration.

It is uncertain whether early fall chinook salmon are still present in the Lostine River drainage. The timing of surveys being conducted for spring chinook salmon in the Wallowa and Lostine River drainage is insufficient for the purpose of identifying the presence of early fall chinook in these river systems (Bryson 1987). A number of mature chinook salmon in pre-spawning condition (i.e., no apparent fin erosion) were observed holding in a deep pool within Reach 3 of the Lostine River by R2 during mid-September 1996. This observations was made following the peak spawning period of spring chinook salmon; redds of spawning spring chinook were evident throughout this reach. The presence of these fish during mid-September suggested that they were early fall chinook salmon, or very late spawning spring chinook salmon. Early fall chinook salmon, if still present in the Lostine River, would be expected to be more adversely affected by upstream passage problems caused by low flow conditions than the spring race of fish. This is because the peak upstream migration period of early fall fish (i.e., July through September) would occur during the lowest yearly flows in the Lostine River. Low flows could also adversely impact spawning of early fall fish in the lower reaches of the Lostine River.

Spring and early fall chinook redds located in Reaches 1 and 2 are subject to periodic dewatering during low flow conditions from August through September. This is especially true of Reach 2, since most of the spawning gravels in this reach are located along the margins of the stream where the potential for redd stranding is greatest. Fortunately, the most important spawning areas for spring chinook salmon are located in Reach 3 and are consequently not subject to irrigation related reductions in flows. Natural low flow conditions may continue through January in the Lostine River due to freezing conditions and precipitation in the form of snow. However, flows during this period are not expected to decline below 23 cfs (90 percent exceedance flow for December and January) following cessation of water withdrawals for irrigation in October. Impacts on incubating eggs and embryos would be expected to be greatest during the irrigation season, when flows in the lower reaches of the river can decline below 10 cfs.

The quantity of spawning gravels for chinook salmon in the lower reaches of the Lostine River has likely been reduced over historic levels due to channelization. A scarcity of spawning gravels was evident in Reach 2, the most channelized of the four study reaches. Channelization has also substantially reduced the amount of holding habitat (i.e., deep pools) required by salmon and steelhead prior to spawning. The total amount of habitat provided by pools in Reaches 1 and 2 was much smaller than that in Reach 3, which is less impacted by channelization.

Low flow conditions also degrade the quantity and quality of chinook salmon rearing habitat in the lower reaches of the Lostine River. Low flow conditions resulting from irrigation withdrawals (i.e., < 10 cfs) result in habitat area values which are less than 35 percent of the maximum HA for juvenile chinook salmon in Reach 1. Flows in Reach 1 occasionally decline to 5 cfs, which provides only 16 percent of the maximum HA value for juvenile chinook salmon in this reach. The impacts of low flow conditions on juvenile rearing habitat is compounded by the adverse impacts of physical disturbance to habitat in Reaches 1 and 2. Habitat in both reaches has been modified by channelization, which has reduced the availability of important habitat features for rearing fish including deep pools, woody debris accumulations, and overhanging banks.

5.4.2 Coho Salmon

Low flows and degraded habitat conditions in the lower reaches of the Lostine River would likely have a greater impact on coho salmon, if reintroduced to this system, than that on spring and early fall chinook salmon. Historical records suggest that coho salmon spawning occurred mainly in the lower reaches of the Lostine River, those areas which are presently most impacted by low flow conditions and physical habitat disturbance (e.g., channelization). Holding habitat for adult coho salmon would likely be limited by low flows and the lack of deep pools during the September and October holding period of this species in the Lostine River. Peak spawning of coho would be expected to occur in October and November after the end of the irrigation season. Consequently, impacts of low flows on spawning coho salmon would not be expected to be high. Low flow conditions during the summer and fall would likely have the greatest impact on the juvenile life stage of coho salmon, which would be expected to rear in the lower reaches of the river at least a year prior to smolting. Juvenile coho salmon prefer deep pools with abundant cover provided by woody debris, overhanging banks, or large boulders. These types of habitat are rare in the lower Lostine River due to the combined effects of low flows and channelization. However, pool habitat has improved substantially within Reach 1 of the river below the Highway 12 bridge (pers. comm., Don Bryson, NPT).

5.4.3 Steelhead Trout

Steelhead trout is likely the anadromous fish species least impacted by the low flow conditions in the Lostine River. This is because the most important spawning and rearing areas for steelhead trout are found in the upper Lostine River, which is unaffected by irrigation diversion and channelization. Upstream passage is not an important concern for steelhead, since the peak

migration period of this species in the Lostine River occurs during months having high flows (March through May). However, a significant amount of rearing habitat of steelhead trout in the Lostine River is lost in Reaches 1 and 2 due to the impacts of low flows combined with physical habitat disturbance. Flows of 10 cfs provide 36 percent of the maximum HA value for juvenile steelhead (and rainbow trout) in Reach 1. Flows of 5 cfs provide only 26 percent of the maximum HA value for juvenile steelhead (and rainbow trout) in this same reach. Physical habitat disturbances including channelization, bank erosion, and channel braiding further reduce the quality of rearing habitat for steelhead in Reaches 1 and 2.

5.4.4 Rainbow Trout and Bull Trout

The best habitat conditions for rainbow trout and bull trout are presently found in the upper Lostine River, which is unaffected by irrigation diversions and channelization. However, the amount of habitat available to rainbow trout and bull trout in the lower reaches of the Lostine River has been substantially reduced by low flow conditions. Flows of 10 cfs provide only 7 percent and 12 percent of the maximum HA for adult rainbow trout and bull trout, respectively, in Reach 1. Flows of 5 cfs provide only 4 percent and 8 percent of the maximum HA for adult rainbow trout and bull trout, respectively, in this same reach. Habitat conditions for these resident trout species in the lower reaches of the river have been further degraded by channelization, bank erosion, and channel braiding. These conditions have resulted in a reduction in the frequency and distribution of deep pools, woody debris accumulations, and the "pocket water" habitat types preferred by juvenile and adult rainbow trout and bull trout.

5.5 MANAGEMENT RECOMMENDATIONS

Provisional instream flow goals for Reaches 1 and 2 of the Lostine River were derived on a monthly basis by examining flow versus habitat relationships for several "indicator" fish species and life stages (Table 5-1). These species and life stages were chosen because they represent critical life stages to the production of important resident and anadromous fish in the Lostine River, and because flows provided for these species/life stages would result in substantially improved habitat conditions for other fish species and life stages present in the river. Adult rainbow trout were selected to establish instream flow goals in Reach 1 from October to March, and in Reach 2 throughout the entire year. Steelhead trout spawning was used to establish instream flow goals for Reach 1 from April through June, and chinook salmon spawning was used to establish instream goals in this reach from July though September (Table 5-1). Spawning was

not considered in establishing instream flow recommendations for Reach 2 because spawning gravels are scarce in this reach. Moreover, most of the gravels in this reach are located along the channel margin and subject to dewatering during natural low flow periods; flow targeted for providing good spawning conditions in this reach would ultimately result in very few successful redds. The fry life stage was not considered in setting instream flow goals for the Lostine River, since fry are present for a relatively short time and are generally restricted to margin habitats along the stream channel. Consequently, flows are probably not a problem to this life stage.

The goal of achieving maximum habitat conditions for fish (i.e., highest HA values) in the context of instream flow studies is laudable, but may be difficult or impossible to attain due to limitations imposed by the natural flow regime. This is especially true of rivers and streams lacking upstream sources of water storage (e.g., large reservoirs) which can be used to provide optimal flows during natural low flow periods. This is certainly the case of the Lostine River, in which optimal flows for many species and life stages (e.g., adult rainbow trout) exceed natural flows during several months of the year. For this reason, it is important to consider the natural hydrology of a river prior to establishing minimum instream flow recommendations or goals. Median flows in the Lostine River during those months having the lowest flows (i.e., September through May) average 42 cfs (see Table 5-1). We have provisionally set monthly instream flow goals which provide 50 percent of maximum habitat (HA values) for each indicator species and life stage, since these goals are attainable under the natural flow regime of the Lostine River.

The provisional minimum instream flow goals for Reach 1 of the Lostine River are 45 cfs from January through March, 60 cfs from April through June, and 45 cfs from July through December (Table 5-1). For Reach 2, the provisional minimum instream flow goal is 25 cfs for all months of the year (Table 5-1). However, higher flows may need to be provided in Reach 2 to meet minimum instream flow goals for Reach 1. It should be recognized that these instream flow goals are most applicable to those periods of the year when flows are diverted from the Lostine River for irrigation (i.e., May through September).

These instream flow goals would provide substantially improved habitat conditions for the other species and life stages of resident and anadromous salmonids present (or historically present) in the Lostine River compared to those occurring under existing flow conditions. The 45 cfs instream flow goal in Reach 1 would result in HA values which are 95 percent of optimal for juvenile chinook salmon, 98 percent of optimal for juvenile coho salmon, 90 percent of optimal for juvenile steelhead/rainbow trout, 91 percent of optimal for juvenile bull trout, and 65 percent

of optimal for adult bull trout. The 25 cfs instream flow goal in Reach 2 would result in HA values which are 100 percent of optimal for juvenile chinook salmon and juvenile coho salmon, 89 percent of optimal for juvenile steelhead/rainbow trout, 91 percent of optimal for juvenile bull trout, and 64 percent of optimal for adult bull trout.

Provided that flows less than 40 cfs occur during August and September, additional provisions would need to be made for upstream migration of spring and early fall chinook salmon to spawning areas located in the middle reaches of the river. Based upon the results of the passage analysis conducted during this study, periodic flow releases equaling or exceeding 40 cfs should be provided to allow chinook salmon to successfully migrate upstream through Reaches 1 and 2 of the Lostine River.

Non-flow management goals for the Lostine River include restoration of natural channel conditions in key sections of Reaches 1 and 2, with emphasis on development of more deep pool habitats. Reach 1 in particular also requires the development of more habitat structure and cover, which could include woody debris, overhanging banks, and large boulders. Rehabilitation of the channel in sections undergoing bank erosion and channel braiding in Reach 1, and below the discontinued gravel mining operation in Reach 3, is also recommended.

Table 5-1. Provisional minimum instream flow goals compared to attainable (i.e., natural) flows for Reaches 1 and 2 of the Lostine River, Oregon.

Month	Natural Median Flow (cfs)	Natural 90% Exceedance Flow (cfs)	REACH 1		REACH 2	
			Target Species & Life Stage	50% of Maximum HA	Target Species & Life Stage	50% of Maximum HA
January	40	23	Rainbow Trout Adult	45	Rainbow Trout Adult	25*
February	40	23	Rainbow Trout Adult	45	Rainbow Trout Adult	25*
March	47	26	Rainbow Trout Adult	45	Rainbow Trout Adult	25*
April	114	48	Steelhead Spawning	60	Rainbow Trout Adult	25*
May	451	183	Steelhead Spawning	60	Rainbow Trout Adult	25*
June	730	376	Steelhead Spawning	60	Rainbow Trout Adult	25*
July	297	94	Chinook Salmon Spawning	45	Rainbow Trout Adult	25*
August	68	37	Chinook Salmon Spawning	45	Rainbow Trout Adult	25*
September	44	26	Chinook Salmon Spawning	45	Rainbow Trout Adult	25*
October	41	25	Rainbow Trout Adult	45	Rainbow Trout Adult	25*
November	47	26	Rainbow Trout Adult	45	Rainbow Trout Adult	25*
December	43	23	Rainbow Trout Adult	45	Rainbow Trout Adult	25*

* A higher minimum flow may need to be provided in this reach to meet minimum flow goals in Reach 1.

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APPENDIX A

Original and Corrected 1991 Habitat Survey Data

Table A-1. Original and corrected habitat distance data (source: ODFW 1991 survey).

Unit Number	Original Habitat Code*	Original Length (m)	Corrected Length (m)	Cumulative Distance (m)	Habitat Type**	Comments
1	RI	170	225	225	RF	Lower end of Reach 1
2	GL	25	33	258	RF	
3	RI	10	13	271	RF	
4	LP	20	26	298	PL	
5	RI	50	66	364	RF	
6	GL	50	66	430	RF	
7	BW	6	0	430	PL	
8	GL	80	0	430	RF	
9	RI	55	73	503	RF	
10	GL	35	46	550	RF	
11	RI	90	119	669	RF	
12	LP	30	40	709	PL	
13	RI	20	26	735	RF	
14	GL	40	0	735	RF	
15	GL	45	60	795	RF	
16	RI	15	20	814	RF	
17	GL	15	20	834	RF	
18	RI	60	79	914	RF	
19	GL	45	0	914	RF	
20	RI	25	0	914	RF	
21	GL	20	26	940	RF	
22	RI	40	53	993	RF	
23	RI	20	0	993	RF	
24	GL	15	20	1013	RF	
25	RI	270	358	1371	RF	
26	RI	55	0	1371	RF	
27	RB	15	20	1391	RB	
28	GL	75	99	1490	RF	
29	RI	650	861	2351	RF	
30	GL	45	60	2410	RF	
31	SP	30	40	2450	PL	
32	RI	180	199	2649	RF	
33	SC	5	7	2655	PL	
34	GL	90	119	2775	RF	
35	SP	15	20	2794	PL	
36	RB	25	33	2828	RB	
37	RI	120	159	2986	RF	
38	LP	18	24	3010	PL	
39	RI	160	212	3222	RF	
40	RB	50	66	3288	RB	
41	RI	230	305	3593	RF	
42	RB	15	20	3613	RB	
43	LP	25	33	3646	PL	
44	RI	250	331	3977	RF	
45	LP	10	13	3990	PL	
46	RI	8	11	4001	RF	
47	LP	20	26	4027	PL	

Table A-1. (continued).

Unit Number	Original Habitat Code*	Original Length (m)	Corrected Length (m)	Cumulative Distance (m)	Habitat Type**	Comments
48	RI	35	46	4074	RF	
49	RI	50	0	4074	RF	
50	LP	20	26	4100	PL	
51	RI	70	93	4193	RF	
52	LP	55	73	4266	PL	
53	RB	12	16	4282	RB	
54	RI	180	238	4520	RF	
55	LP	40	53	4573	PL	
56	RB	15	20	4593	RB	
57	SP	30	40	4633	PL	
58	BW	10	0	4633	PL	
59	RI	50	66	4699	RF	
60	SC	7	9	4708	PL	
61	RI	100	132	4841	RF	
62	LP	25	33	4874	PL	
63	RB	10	13	4887	RB	
64	RI	140	185	5072	RF	
65	LP	15	20	5092	PL	
66	RI	70	93	5185	RF	
67	GL	25	33	5218	RF	
68	RI	35	46	5264	RF	
69	LP	15	20	5284	PL	
70	RB	15	20	5304	RB	
71	RI	100	132	5437	RF	
72	SP	12	16	5452	PL	
73	SC	10	13	5466	PL	
74	GL	50	66	5532	RF	
75	RB	25	33	5565	RB	
76	RI	60	0	5565	RF	
77	RI	120	159	5724	RF	
78	LP	10	13	5737	PL	
79	RI	175	232	5969	RF	
80	GL	30	0	5969	RF	
81	RI	50	0	5969	RF	
82	SC	10	13	5982	PL	
83	RI	110	146	6128	RF	
84	GL	35	46	6174	RF	
85	RI	250	331	6505	RF	
86	RB	25	33	6538	RB	
87	RI	40	53	6591	RF	
88	RB	30	40	6631	RB	
89	LP	30	40	6671	PL	
90	RB	35	46	6717	RB	
91	RI	90	119	6836	RF	
92	LP	20	26	6863	PL	
93	RB	15	20	6883	RB	
94	GL	30	40	6923	RF	

Table A-1. (continued).

Unit Number	Original Habitat Code*	Original Length (m)	Corrected Length (m)	Cumulative Distance (m)	Habitat Type**	Comments
95	RB	80	106	7029	RB	
96	RI	35	46	7075	RF	
97	RB	20	26	7101	RB	
98	GL	60	0	7101	RF	
99	RI	30	40	7141	RF	
100	GL	40	53	7194	RF	
101	RB	20	26	7221	RB	
102	RI	25	33	7254	RF	
103	LP	20	26	7280	PL	
104	RB	15	20	7300	RB	
105	RI	210	278	7578	RF	
106	GL	50	66	7644	RF	
107	RB	25	33	7677	RB	
108	RI	300	397	8075	RF	
109	RB	30	40	8114	RB	
110	GL	30	40	8154	RF	Lower end of Reach 2
111	RP	250	331	8485	RF	
112	GL	20	26	8512	RF	
113	SP	8	11	8522	PL	
114	RP	75	99	8622	RF	
115	LP	15	20	8642	PL	
116	RP	60	79	8721	RF	
117	GL	20	26	8748	RF	
118	RP	420	556	9304	RF	
119	DP	25	33	9337	PL	
120	RP	100	132	9469	RF	
121	GL	35	46	9516	RF	
122	RI	12	16	9532	RF	
123	LP	8	11	9542	PL	
124	RP	800	1060	10602	RF	
125	SP	20	26	10628	PL	
126	RP	65	86	10714	RF	
127	PP	7	9	10724	PL	
128	FL	25	33	10757	PL	
129	RP	90	119	10876	RF	
130	LP	45	60	10935	PL	
131	SB	5	7	10942	RB	
132	RP	450	596	11538	RF	
133	LP	12	16	11554	PL	
134	RP	210	278	11832	RF	
135	RI	80	0	11832	RF	
136	LP	30	40	11872	PL	
137	RP	450	596	12468	RF	
138	LP	15	20	12488	PL	
139	IP	5	0	12488	PL	
140	RP	600	795	13282	RF	
141	FL	20	26	13309	PL	

Table A-1. (continued).

Unit Number	Original Habitat Code*	Original Length (m)	Corrected Length (m)	Cumulative Distance (m)	Habitat Type**	Comments
142	LP	75	99	13408	PL	
143	RP	165	212	13620	RF	
144	GL	25	33	13653	RF	
145	RP	45	60	13713	RF	
146	GL	30	40	13752	RF	
147	RI	15	20	13772	RF	
148	LP	61	81	13853	PL	
149	GL	25	33	13886	RF	
150	RI	12	16	13902	RF	
151	GL	40	53	13955	RF	
152	SP	15	20	13975	PL	
153	RI	15	20	13995	RF	
154	LP	15	20	14015	PL	
155	RI	8	11	14025	RF	
156	GL	70	93	14118	RF	
157	RP	60	79	14197	RF	
158	SB	2	3	14200	RB	
159	GL	85	113	14313	RF	Lower end of Reach 3
160	RI	50	66	14379	RF	
161	BW	12	16	14395	PL	
162	SL	3	4	14399	PL	
163	DP	60	79	14478	PL	
164	GL	75	99	14577	RF	
165	RI	20	26	14604	RF	
166	GL	25	33	14637	RF	
167	RI	90	119	14756	RF	
168	BW	30	40	14796	PL	
169	GL	110	146	14942	RF	
170	RI	25	33	14975	RF	
171	GL	85	113	15087	RF	
172	RI	10	13	15101	RF	
173	LP	55	73	15173	PL	
174	RI	40	53	15226	RF	
175	LP	85	113	15339	PL	
176	RI	30	40	15379	RF	
177	LP	70	93	15471	PL	
178	RI	14	19	15490	RF	
179	GL	45	60	15550	RF	
180	RI	20	26	15576	RF	
181	GL	35	46	15622	RF	
182	RI	25	33	15656	RF	
183	LP	30	40	15695	PL	
184	RP	60	79	15775	RF	
185	BW	8	0	15775	PL	
186	LP	45	60	15834	PL	
187	SP	15	20	15854	PL	
188	RP	50	66	15920	RF	

Table A-1. (continued).

Unit Number	Original Habitat Code*	Original Length (m)	Corrected Length (m)	Cumulative Distance (m)	Habitat Type**	Comments
189	GL	35	46	15967	RF	
190	RP	70	93	16059	RF	
191	GL	110	146	16205	RF	
192	SP	15	20	16225	PL	
193	GL	130	172	16397	RF	
194	LP	40	53	16450	PL	
195	GL	65	86	16536	RF	
196	LP	15	20	16556	PL	
197	GL	40	53	16609	RF	
198	RI	60	79	16689	RF	
199	GL	35	46	16735	RF	
200	LP	30	40	16775	PL	
201	RI	8	11	16785	RF	
202	LP	25	33	16818	PL	
203	RI	5	7	16825	RF	
204	LP	45	60	16885	PL	
205	GL	150	199	17083	RF	
206	LP	30	40	17123	PL	
207	RI	40	53	17176	RF	
208	LP	25	33	17209	PL	
209	GL	90	119	17328	RF	
210	RI	60	79	17408	RF	
211	LP	30	40	17447	PL	
212	RI	55	73	17520	RF	
213	GL	80	106	17626	RF	
214	BW	10	13	17639	PL	
215	RI	45	60	17699	RF	
216	BW	10	13	17712	PL	
217	LP	15	20	17732	PL	
218	RI	80	106	17838	RF	
219	LP	35	46	17884	PL	
220	GL	30	40	17924	RF	
221	RI	10	13	17937	RF	
222	GL	45	60	17997	RF	
223	RI	100	132	18129	RF	
224	LP	10	13	18143	PL	
225	RI	10	13	18156	RF	
226	GL	50	66	18222	RF	
227	RI	50	66	18288	RF	
228	RI	22	0	18288	RF	
229	GL	16	0	18288	RF	
230	LP	14	0	18288	PL	
231	RI	35	0	18288	RF	
232	GL	25	33	18322	RF	
233	RI	60	79	18401	RF	
234	GL	25	33	18434	RF	
235	BW	10	0	18434	PL	

Table A-1. (continued).

Unit Number	Original Habitat Code*	Original Length (m)	Corrected Length (m)	Cumulative Distance (m)	Habitat Type**	Comments
236	RP	350	464	18898	RF	
237	BW	15	0	18898	PL	
238	LP	12	16	18914	PL	
239	RP	180	238	19152	RF	
240	RB	65	86	19238	RB	
241	GL	15	20	19258	RF	
242	RP	70	93	19351	RF	
243	LP	8	11	19361	PL	
244	SB	2	3	19364	RB	
245	RP	160	212	19576	RF	Lower end of Reach 4
246	LP	10	13	19589	PL	
247	RP	200	265	19854	RF	
248	RB	30	40	19894	RB	
249	RP	50	66	19960	RF	
250	RB	55	73	20033	RB	
251	RP	50	66	20099	RF	
252	SP	10	13	20112	PL	
253	SB	2	3	20115	RB	
254	RB	230	305	20419	RB	
255	SB	1	1	20421	RB	
256	RB	140	185	20606	RB	
257	RP	75	0	20606	RF	
258	RP	50	66	20672	RF	
259	RB	20	26	20699	RB	
260	RP	35	46	20745	RF	
261	SB	1	1	20746	RB	
262	GL	20	26	20773	RF	
263	RB	400	530	21303	RB	Silver Creek Confluence

Original Habitat Code	Description
GL	Glide
BW	Pool - Backwater
DP	Pool - Dammed
IP	Pool - Isolated
LP	Pool - Lateral Scour
PP	Pool - Plunge
SP	Pool - Straight Scour
RB	Rapid/Boulders
RI	Riffle
RP	Riffle w/ Pockets
SB	Step/Boulders
SC	Step/Cobble
SL	Step/Log
SS	Step/Structure

**Assigned Habitat Type	Description
RF	Riffles, Runs, and Glides
RB	Cascades and Rapids
PL	Pools

APPENDIX B

Hydraulic Calibration Procedures

APPENDIX B
HYDRAULIC CALIBRATION PROCEDURES

Calibration of the hydraulic model involved two basic steps: first, accurately predicting water surface elevations at each transect over the entire range of flows modeled; and second, realistically distributing velocities across each transect over the same set of modeled flows.

1.0 RATING CURVE CALIBRATION

The first calibration procedure applied to the Lostine River IFG4 models was accurately predicting water surface elevations (WSEs) over the entire range of simulated flows; i.e., development of an accurate rating curve. Substantial deviations in WSE predictions can potentially result in erroneous velocity and depth calculations, especially at the highest and lowest discharges modeled. For the Lostine study, the hydraulic model was calibrated using only the high flow velocity data. The high flow data set was used because it required less manipulation to provide a reasonable distribution of flow across the channel. Two different procedures were used to predict water surface elevations for each simulation discharge. Calibration procedures were considered a success when: 1) predicted water surface elevations for a given discharge were very close (within 0.10 ft) to those measured in the field at the same discharge; 2) water surface elevation values among transects were reasonable at the highest and lowest discharges modeled (e.g., water did not flow in an upward direction; WSEs at adjacent transects did not cross over at higher flows); and 3) velocities calculated under WSEs predicted by the model were not unusually high or low for the flow considered.

Two different WSE calibration methods were employed in this study: a log-log stage-discharge regression method, and a Manning's equation based method. The stage-discharge method was generally the best for modeling WSEs in pools and deep runs, while the Manning's equation based method was generally best for modeling WSEs in riffles and shallow runs.

Rating curves using the stage-discharge regression method were calculated using the PHABSIM program STGQS4 (Milhous et al. 1989). The general calibration procedure involved with this method involved iteratively changing the stage of zero flow (SZF) value until the best possible fit could be obtained from the log-log regression equation.

Rating curves developed using the Manning's equation method were calculated using the PHABSIM program MANSQ (Milhous et al. 1989). This program uses Manning's Equation to predict WSEs based upon channel geometry and roughness (Bovee and Milhous 1978). Calibration of MANSQ involved iteratively adjusting a coefficient which varied channel roughness ("Beta" value) with increasing discharge. Calibration was considered successful when WSEs calculated by MANSQ closely approximated those measured in the field at the same discharge and provided a reasonable estimate of conditions at the highest flow modeled. Once calibrated, WSEs predicted by STGQS4 and MANSQ for all simulation flows were inserted into the appropriate IFG4 input data files of both the low, medium, and high flow data sets (i.e., entered on WSL lines).

The rating curves developed at the Lostine River transects using these calibration methods were accurate over the entire range of flows modeled (Tables B-1 through B-4). Modeling errors (i.e., the difference between measured and predicted values) varied between 0.00 and 0.11 ft, with mean absolute errors for flows not exceeding 0.10 ft at any transect. Mean absolute errors varied between 0.00 and 0.04 ft at most transects. Extrapolation errors were minimal because water surface elevations were not predicted for flows beyond the highest actually measured. The highest measured flow in the Lostine River was approximately 1,000 cfs, and was close to bankfull at this point. The hydraulic model was not used to simulate hydraulic conditions for flows higher than 1,000 cfs.

2.0 VELOCITY CALIBRATION

The hydraulic calibration procedure also involved distributing velocities across each transect in a realistic way over all discharges modeled. Obtaining a realistic velocity distribution over a wide range of flows can be challenging, since the intrinsic variability in velocities across transects at lower flows often results in unrealistic velocity predictions when extrapolated to higher flows. The overall calibration goal is to maintain the variability in velocities across a transect at lower flows, while at the same time keeping velocities at higher flows from becoming unreasonably high or low. Each transect was individually calibrated to further increase the accuracy of velocity predictions; adjustments were made by modification of channel roughness coefficients ("N" values) used by IFG4 to distribute velocities at all simulation flows. This was accomplished by applying appropriate "NMIN" and "NMAX" values to transects at each site (Table B-5).

The NMIN and NMAX values apply constraints on the minimum and maximum channel roughness values, respectively, applied across a transect by the IFG4 hydraulic simulation program. Velocity simulation problems for the medium and high flow models typically involved the underestimation of velocities along the edge of the channel at higher simulation flows (i.e., "edge roughness"; Bovee and Milhous 1978), and overestimation of velocities in verticals near the center of the channel having low roughness values. Different sets of NMIN and NMAX values were applied to the low flow (5 to 50 cfs), medium flow (50 to 250 cfs), and high flow (250 to 1,000 cfs) hydraulic simulation files. Higher NMIN and lower NMAX values were applied to high flow simulations compared to the medium and low flow simulations (Table B-5). This tends to reduce variation in velocities at the higher simulated flows, and prevents velocity predictions which are unrealistically high (i.e., > 15 fps), or unrealistically low (e.g., 1.0 fps velocity adjacent to a 12.0 fps velocity). This procedure reflects a hydraulically real phenomena, and velocity distributions in most streams and rivers become increasingly homogenous at higher flows (this can be attributed to the declining influence of the river bed on velocities when channel depths increase).

Table B-1. Water surface elevation calibration summary for Reach 1 of Lostine River, Oregon.

Site	Transect	Habitat Type	Calibration Method 1/	Stage of Zero Flow (ft)	MANSQ Beta 2/	Observed WSE (ft)			Predicted WSE (ft)			WSE Difference (ft)			Mean Absolute Error (ft)
						Low	Med.	High	Low	Med.	High	Low	Med.	High	
1	1	Riffle/Rapid	MANSQ	80.10	-0.05	80.58	80.89	82.95	80.66	80.89	82.95	0.08	0.00	0.00	0.03
	2	Riffle	MANSQ	82.20	-0.10	82.93	83.15	85.10	82.94	83.15	85.08	0.01	0.00	-0.02	0.01
	3	Run	MANSQ	85.00	-0.50	85.87	86.13	87.65	85.93	86.13	87.69	0.06	0.00	0.04	0.03
	4	Pool	STG-Q	85.30	NA	86.42	86.66	88.43	86.42	86.66	88.43	0.00	0.00	0.00	0.00
2	1	Riffle/Run	MANSQ	94.50	-0.54	95.57	95.92	98.02	95.61	95.92	98.00	0.04	0.00	-0.02	0.02
	2	Pool	STG-Q	92.90	NA	96.14	96.54	98.17	96.14	96.54	98.17	0.00	0.00	0.00	0.00
	3	Riffle/Rapid	MANSQ	99.20	-0.80	100.51	100.75	101.91	100.56	100.75	101.91	0.05	0.00	0.00	0.02
	4	Run	STG-Q	98.40	NA	101.47	101.81	103.16	101.47	101.81	103.16	0.00	0.00	0.00	0.00
3	1	Pool	STG-Q	96.60	NA	97.39	97.71	99.59	97.39	97.71	99.59	0.00	0.00	0.00	0.00
	2	Riffle/Rapid	MANSQ	98.00	-0.30	98.86	99.21	101.37	98.89	99.21	101.37	0.03	0.00	0.00	0.01
	3	Riffle	MANSQ	99.80	-0.28	100.54	100.82	102.55	100.52	100.82	102.65	-0.02	0.00	0.10	0.04
	4	Run	MANSQ	99.80	NA	101.28	101.64	103.31	101.31	101.64	103.29	0.03	0.00	-0.02	0.02
4	1	Riffle/Rapid	MANSQ	95.70	-0.20	96.88	97.35	98.69	96.90	97.35	98.69	0.02	0.00	0.00	0.01
	2	Riffle	MANSQ	97.10	-0.60	97.89	98.22	99.55	97.82	98.22	99.53	-0.07	0.00	-0.02	0.03
	3	Run	MANSQ	99.20	-0.40	100.34	100.61	101.74	100.34	100.61	101.75	0.00	0.00	0.01	0.00
	4	Pool	STG-Q	99.20	NA	100.84	101.31	102.83	100.84	101.30	102.83	0.00	-0.01	0.00	0.00

1/ STG-Q = Stage-Discharge log-log regression method; MANSQ = Manning's Equation based model.
2/ MANSQ Beta Coefficient (NA - not applicable, stage-discharge regression method used).

Table B-2. Water surface elevation calibration summary for Reach 2 of Lostine River, Oregon.

Site	Transect	Habitat Type	Calibration Method [1/]	Stage of Zero Flow (ft)	MANSQ Beta [2/]	Observed WSE (ft)			Predicted WSE (ft)			WSE Difference (ft)			Mean Absolute Error (ft)
						Low	Med.	High	Low	Med.	High	Low	Med.	High	
1	1	Pool	STG-Q	87.30	NA	88.99	89.75	91.87	88.99	89.75	91.87	0.00	0.00	0.00	0.00
	2	Riffle/Rapid	MANSQ	88.80	-0.50	91.35	91.95	93.55	91.46	91.94	93.53	0.11	-0.01	-0.02	0.05
	3	Run/Riffle	STG-Q	92.20	NA	92.63	93.01	94.61	92.63	93.02	94.60	0.00	0.01	-0.01	0.01
	4	Run	MANSQ	92.20	-0.40	93.28	93.68	95.31	93.18	93.68	95.27	-0.10	0.00	-0.04	0.05
2 [3/]	1	Riffle/Run	STG-Q	95.10	NA	95.83	96.23	97.94	95.83	96.23	97.94	0.00	0.00	0.00	0.00
	2	Run	MANSQ	96.20	-0.55	96.96	97.49	100.10	96.88	97.49	100.05	-0.08	0.00	-0.05	0.04
	3	Riffle/Rapid	STG-Q	95.00	NA	95.51	95.96	98.77	95.51	95.96	98.77	0.00	0.00	0.00	0.00
	4	Riffle	MANSQ	88.80	-0.95	89.63	90.02	91.61	89.60	90.02	91.58	-0.03	0.00	-0.03	0.02
3 [3/]	1	Pool	STG-Q	93.10	NA	93.96	94.39	96.18	93.96	94.39	96.18	0.00	0.00	0.00	0.00
	2	Run	STG-Q	95.70	NA	97.93	98.42	99.87	97.93	98.42	99.87	0.00	0.00	0.00	0.00
	3	Riffle	STG-Q	95.00	NA	95.70	96.04	97.41	95.70	96.04	97.41	0.00	0.00	0.00	0.00
	4	Riffle/Rapid	MANSQ	93.30	-0.65	93.82	94.15	95.82	93.73	94.15	95.81	-0.09	0.00	-0.01	0.03

1/ STG-Q = Stage-Discharge log-log regression method; MANSQ = Manning's Equation based model.
2/ MANSQ Beta Coefficient (NA - not applicable, stage-discharge regression method used).
3/ Transects surveyed independently of each other (i.e, WSEs not tied in).

Table B-3. Water surface elevation calibration summary for Reach 3 of Lostine River, Oregon.

Site	Transect	Habitat Type	Calibration Method [1/]	Stage of Zero Flow (ft)	MANSQ Beta [2/]	Observed WSE (ft)			Predicted WSE (ft)			WSE Difference (ft)			Mean Absolute Error (ft)
						Low	Med.	High	Low	Med.	High	Low	Med.	High	
1	1	Riffle	MANSQ	96.90	-0.75	97.33	97.47	98.84	97.22	97.47	98.86	-0.11	0.00	0.02	0.04
	2	Run	STG-Q	96.90	NA	97.37	97.53	99.11	97.37	97.53	99.11	0.00	0.00	0.00	0.00
	3	Pool	STG-Q	96.90	NA	97.44	97.62	99.26	97.44	97.62	99.26	0.00	0.00	0.00	0.00
	4	Riffle/Run	MANSQ	97.20	-0.75	97.76	97.96	99.97	97.74	97.96	99.95	-0.02	0.00	-0.02	0.01
2	1	Riffle	MANSQ	92.80	0.00	93.11	93.38	95.29	93.09	93.38	95.25	-0.02	0.00	-0.04	0.02
	2	Run	STG-Q	93.00	NA	93.35	93.59	95.33	93.35	93.60	95.32	0.00	0.01	-0.01	0.01
	3	Run/Pool	STG-Q	93.00	NA	93.39	93.67	95.47	93.39	93.67	95.47	0.00	0.00	0.00	0.00
	4	Pool	STG-Q	93.00	NA	93.40	93.72	95.66	93.41	93.70	95.68	0.01	-0.02	0.02	0.02
3	1	Riffle	MANSQ	94.30	-0.80	95.60	95.90	97.69	95.57	95.90	97.68	-0.03	0.00	-0.01	0.01
	2	Run	STG-Q	94.60	NA	95.68	96.00	97.85	95.67	96.02	97.84	-0.01	0.02	-0.01	0.01
	3	Run	MANSQ	94.60	-1.60	95.75	96.14	98.09	95.74	96.14	98.08	-0.01	0.00	-0.01	0.01
	4	Pool/Run	STG-Q	95.40	NA	96.03	96.33	98.28	96.03	96.33	98.28	0.00	0.00	0.00	0.00

1/ STG-Q = Stage-Discharge log-log regression method; MANSQ = Manning's Equation based model.

2/ MANSQ Beta Coefficient (NA - not applicable, stage-discharge regression method used).

Table B-4. Water surface elevation calibration summary for Reach 4 of Lostine River, Oregon.

Site	Transect	Habitat Type	Calibration Method [1/]	Stage of Zero Flow (ft)	MANSQ Beta [2/]	Observed WSE (ft)			Predicted WSE (ft)			WSE Difference (ft)			Mean Absolute Error (ft)
						Low	Med.	High	Low	Med.	High	Low	Med.	High	
1	1	Run/Riffle	STG-Q	91.80	NA	95.12	95.39	97.52	95.13	95.38	97.52	0.01	-0.01	0.00	0.01
	2	Pool	STG-Q	91.80	NA	95.12	95.40	97.53	95.13	95.39	97.53	0.01	-0.01	0.00	0.01
	3	Riffle/Rapid	MANSQ	96.20	-1.20	98.15	98.35	99.98	98.15	98.35	99.94	0.00	0.00	-0.04	0.01
	4	Riffle/Rapid	MANSQ	99.90	-1.10	99.72	99.90	102.02	99.66	99.90	102.02	-0.06	0.00	0.00	0.02

1/ STG-Q = Stage-Discharge log-log regression method; MANSQ = Manning's Equation based model.
2/ MANSQ Beta Coefficient (NA - not applicable, stage-discharge regression method used).

Table B-5. Velocity calibration values employed in Lostine River hydraulic simulations.

Reach	Section	Flow	NMAX	NMIN	Slope			
					Transect 1	Transect 2	Transect 3	Transect 4
1	1	Low	0.200	-	0.0030	0.0025	0.0025	0.0005
		Medium	0.070	0.020	0.0030	0.0025	0.0025	0.0005
		High	0.050	0.024	0.0030	0.0025	0.0025	0.0005
	2	Low	0.090	-	0.0025	0.0005	0.0040	0.0025
		Medium	0.070	0.020	0.0025	0.0010	0.0040	0.0025
		High	0.060	0.026	0.0025	0.0020	0.0040	0.0025
	3	Low	0.200	-	0.0005	0.0025	0.0025	0.0025
		Medium	0.100	0.018	0.0005	0.0025	0.0025	0.0025
		High	0.040	0.024	0.0005	0.0025	0.0025	0.0025
	4	Low	0.140	-	0.0025	0.0025	0.0025	0.0010
		Medium	0.100	0.018	0.0025	0.0025	0.0025	0.0015
		High	0.050	0.024	0.0025	0.0025	0.0025	0.0020
2	1	Low	0.100	-	0.0010	0.0025	0.0025	0.0025
		Medium	0.080	0.020	0.0010	0.0025	0.0025	0.0025
		High	0.050	0.024	0.0015	0.0025	0.0025	0.0025
	2	Low	0.140	0.020	0.0025	0.0015	0.0040	0.0025
		Medium	0.080	0.028	0.0025	0.0015	0.0040	0.0025
		High	0.050	0.032	0.0025	0.0015	0.0040	0.0025
	3	Low	0.180	-	0.0025	0.0025	0.0025	0.0025
		Medium	0.120	0.028	0.0025	0.0025	0.0025	0.0025
		High	0.060	0.034	0.0025	0.0025	0.0025	0.0025
3	1	Low	0.300	-	0.0025	0.0025	0.0003	0.0025
		Medium	0.150	0.030	0.0025	0.0025	0.0003	0.0025
		High	0.060	0.034	0.0025	0.0025	0.0003	0.0025
	2	Low	0.300	-	0.0025	0.0020	0.0005	0.0001
		Medium	0.150	0.022	0.0025	0.0020	0.0005	0.0001
		High	0.050	0.024	0.0025	0.0020	0.0005	0.0001
	3	Low	0.300	0.025	0.0025	0.0025	0.0025	0.0025
		Medium	0.150	0.028	0.0025	0.0025	0.0025	0.0025
		High	0.050	0.030	0.0025	0.0025	0.0025	0.0025
4	1	Low	0.300	-	0.0025	0.0005	0.0030	0.0030
		Medium	0.150	0.025	0.0020	0.0005	0.0025	0.0025
		High	0.050	0.030	0.0015	0.0003	0.0020	0.0020

APPENDIX C

Habitat Suitability Curves Used in Lostine River Habitat Simulations

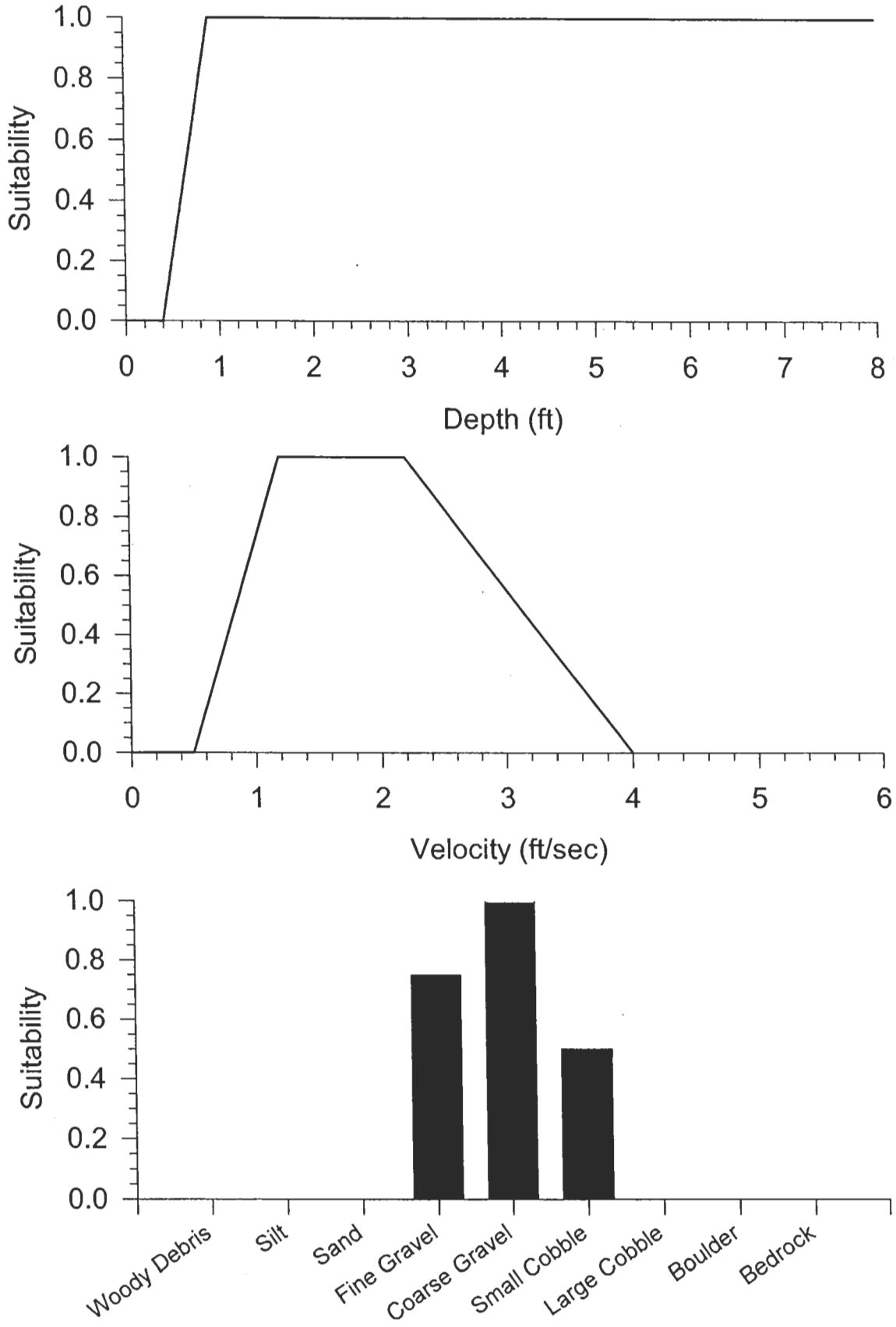


Figure C-1. Habitat suitability criteria for chinook salmon (spring race) spawning.

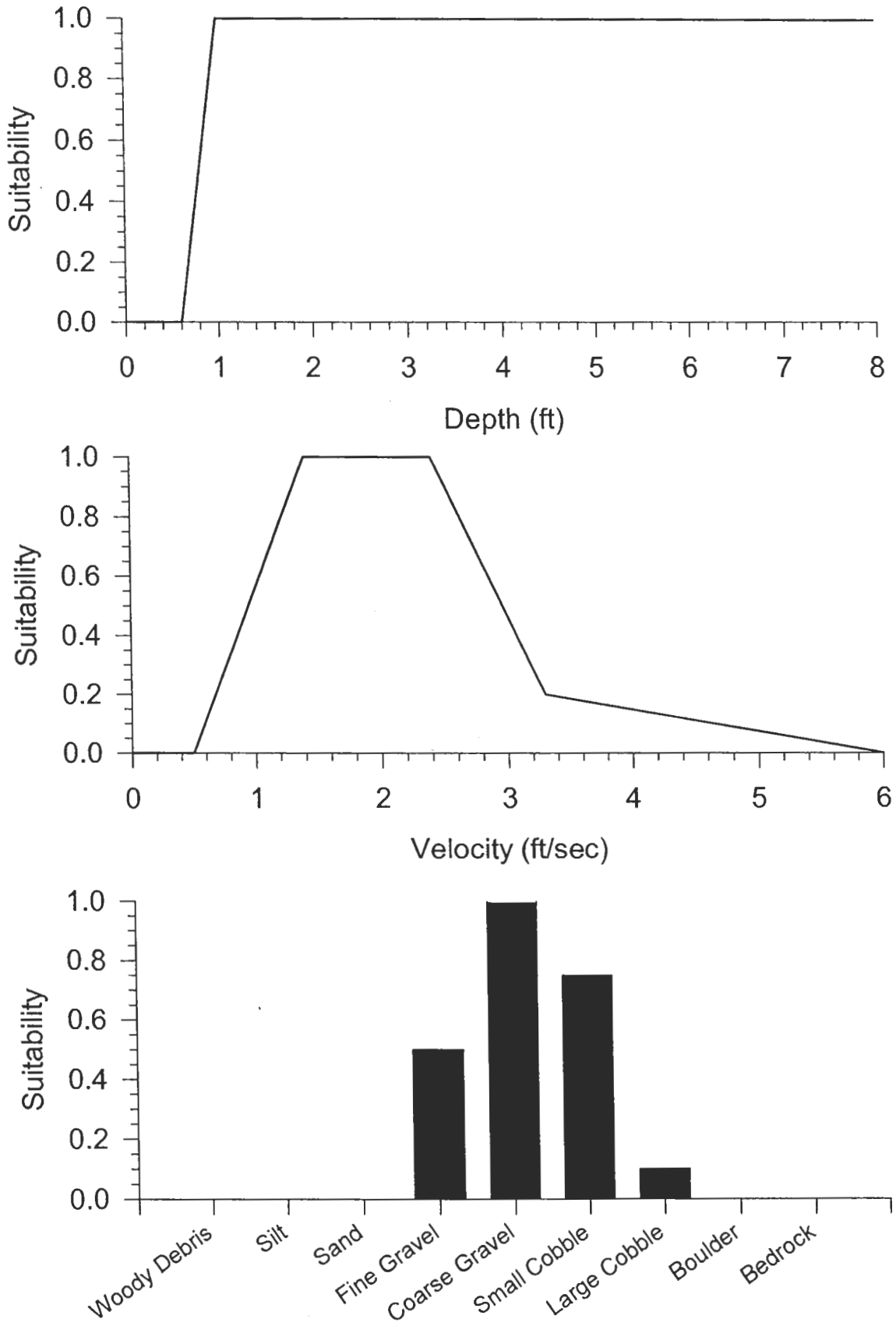
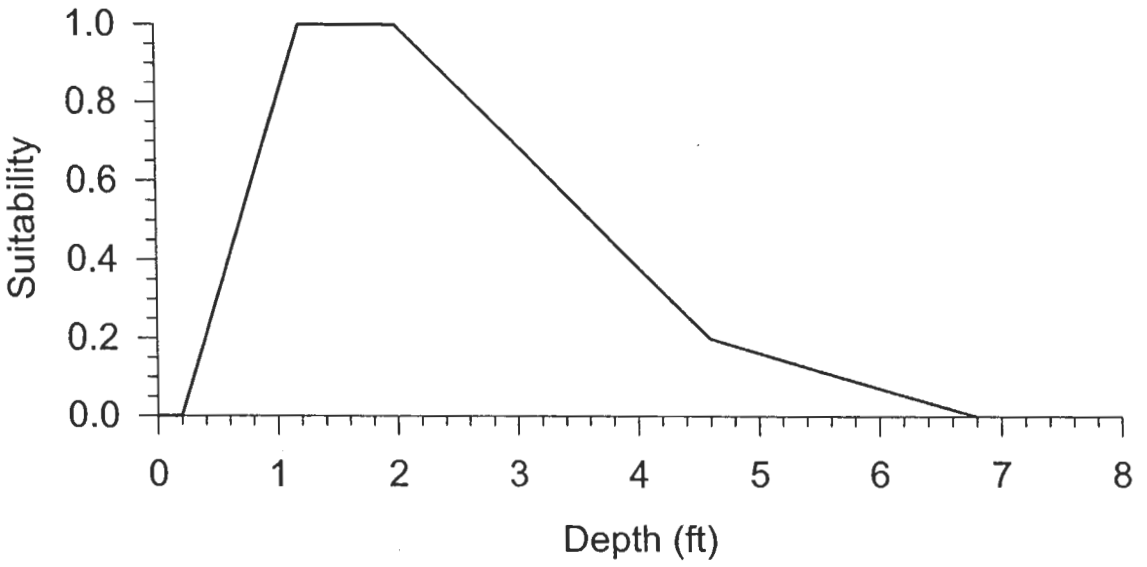
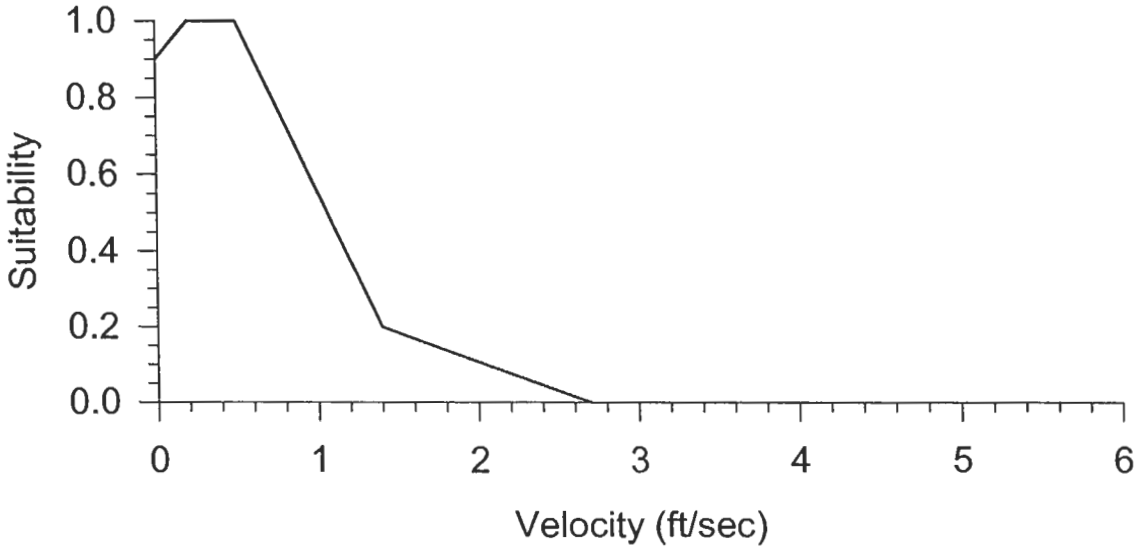


Figure C-2. Habitat suitability criteria for chinook salmon (fall race) spawning.





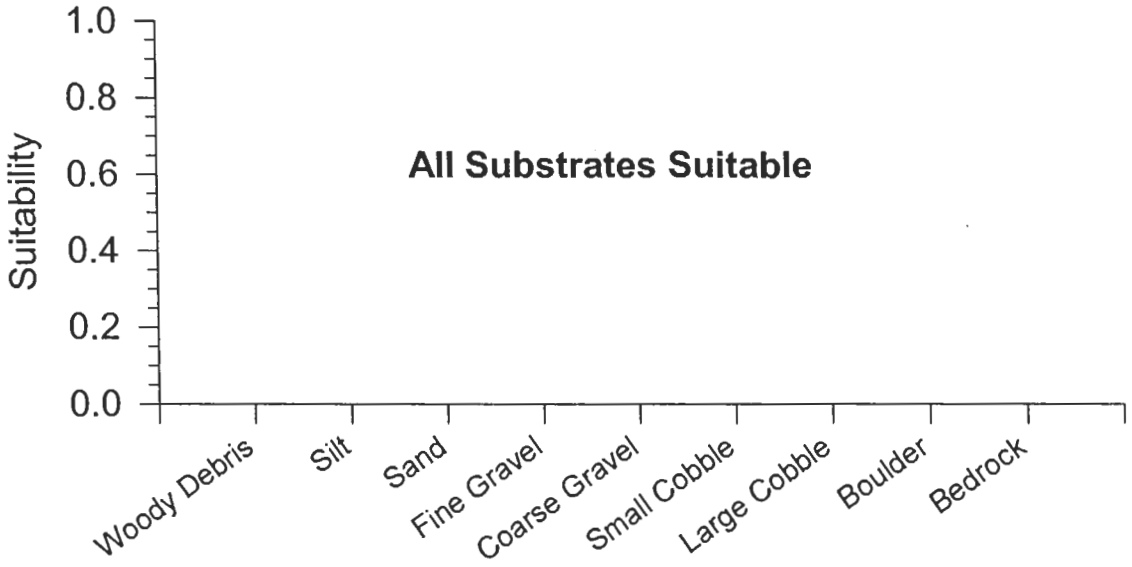
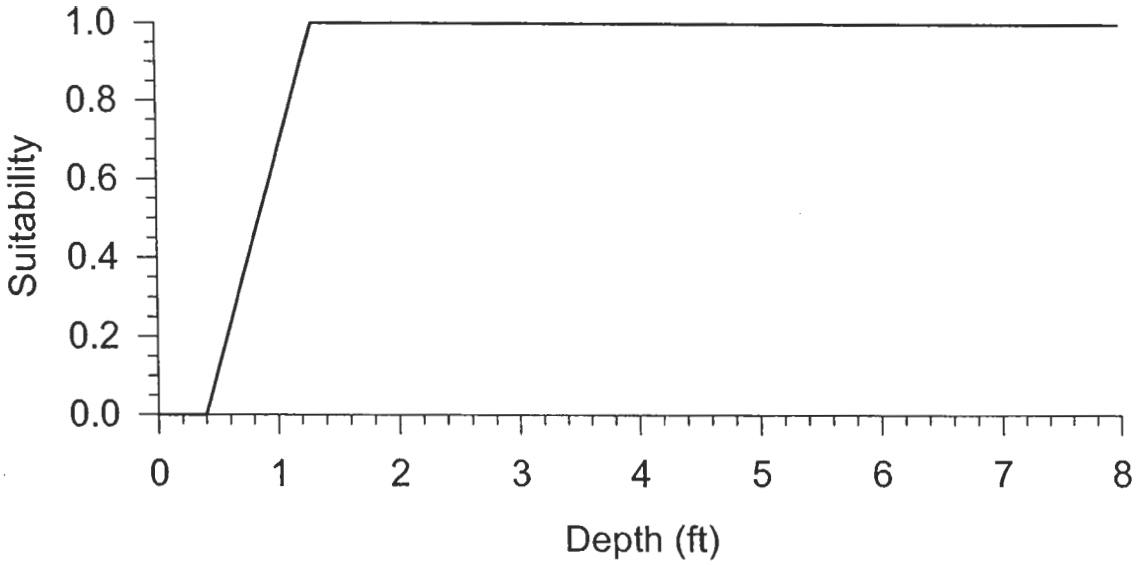
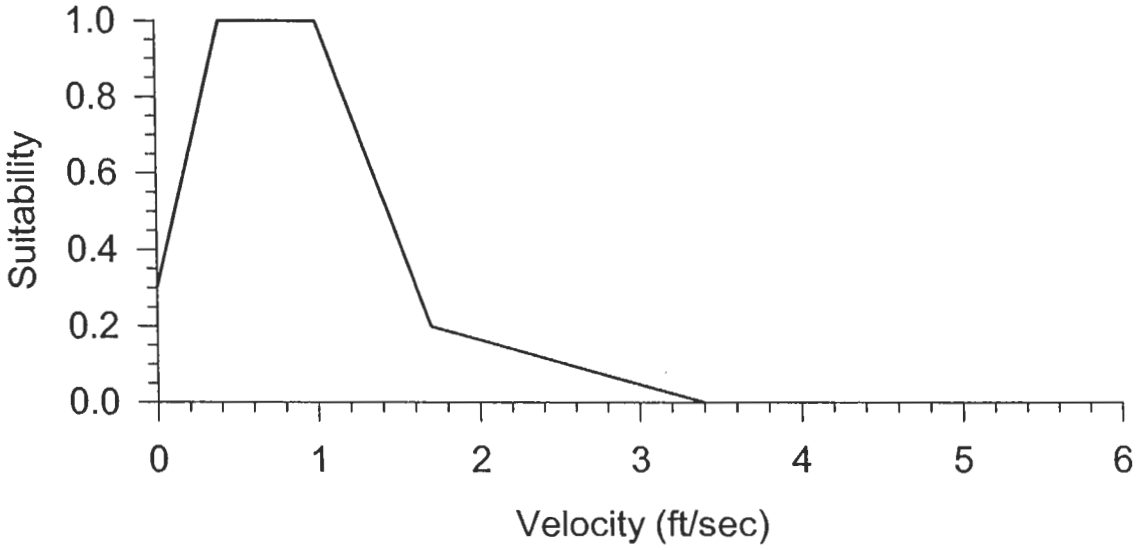


Figure C-3. Habitat suitability criteria for chinook salmon fry.





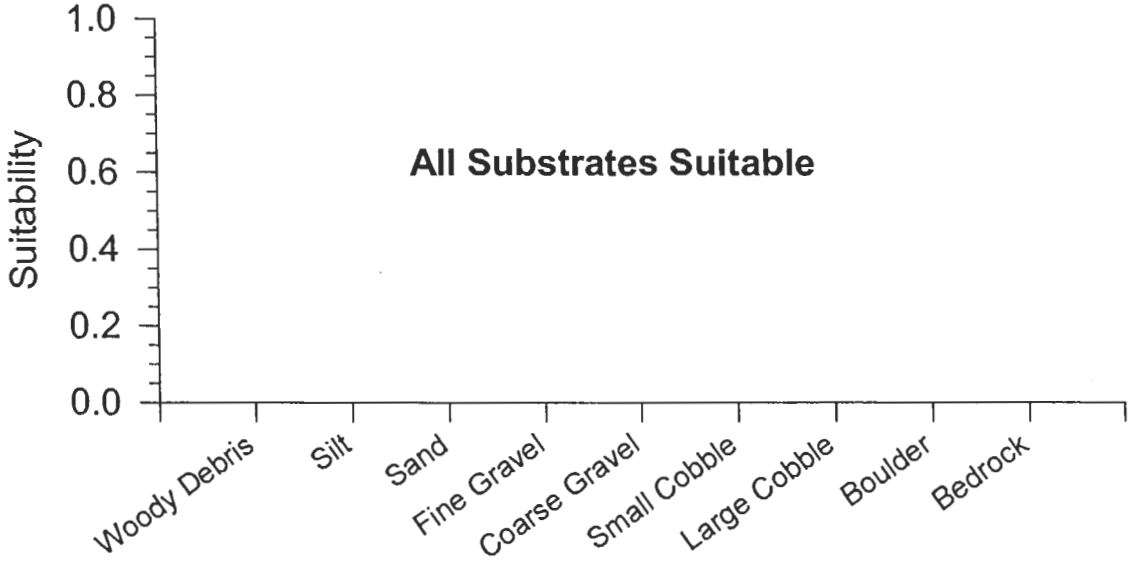


Figure C-4. Habitat suitability criteria for chinook salmon juveniles.

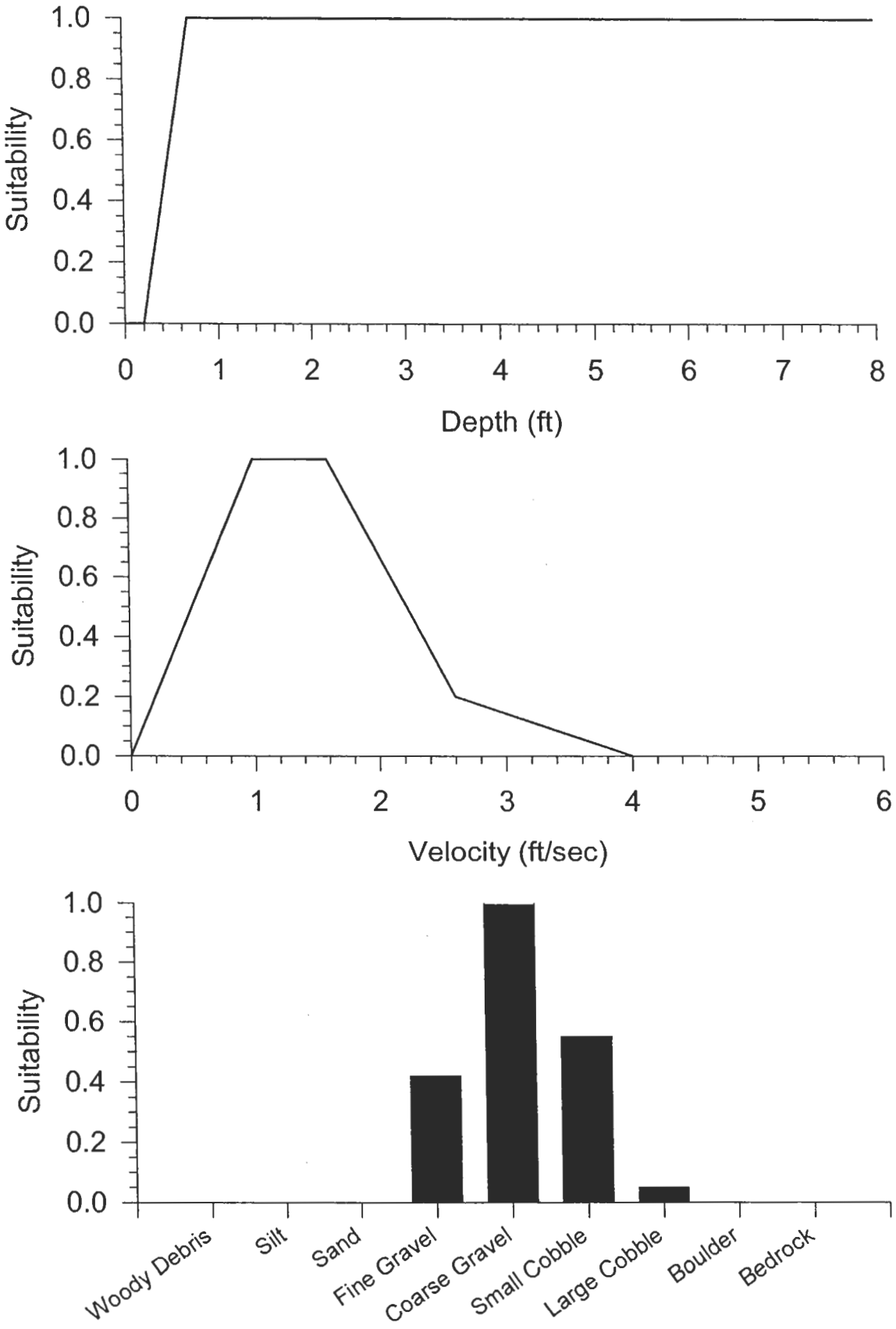
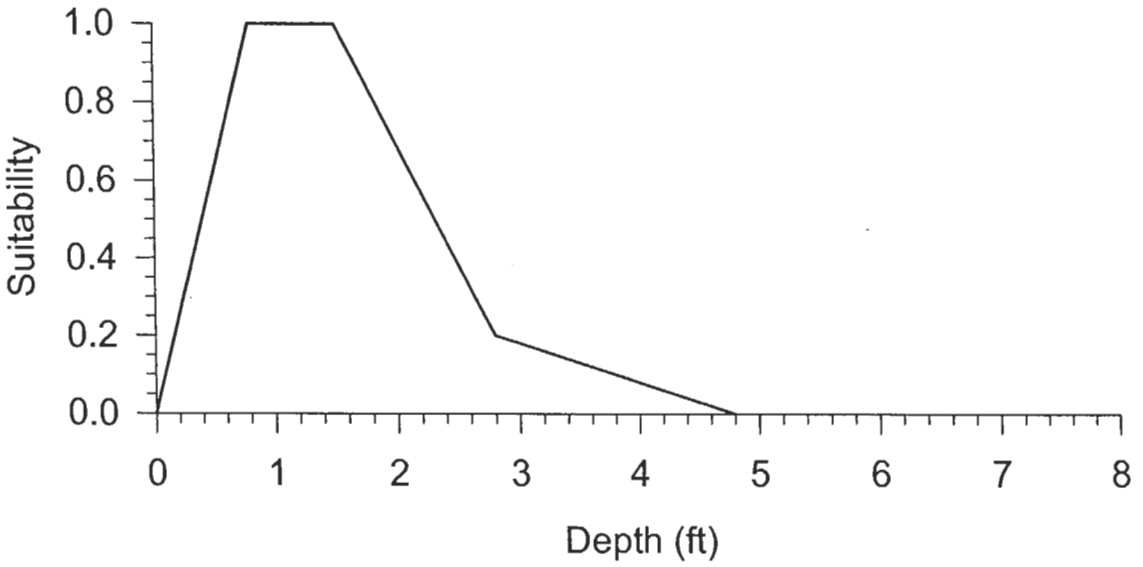
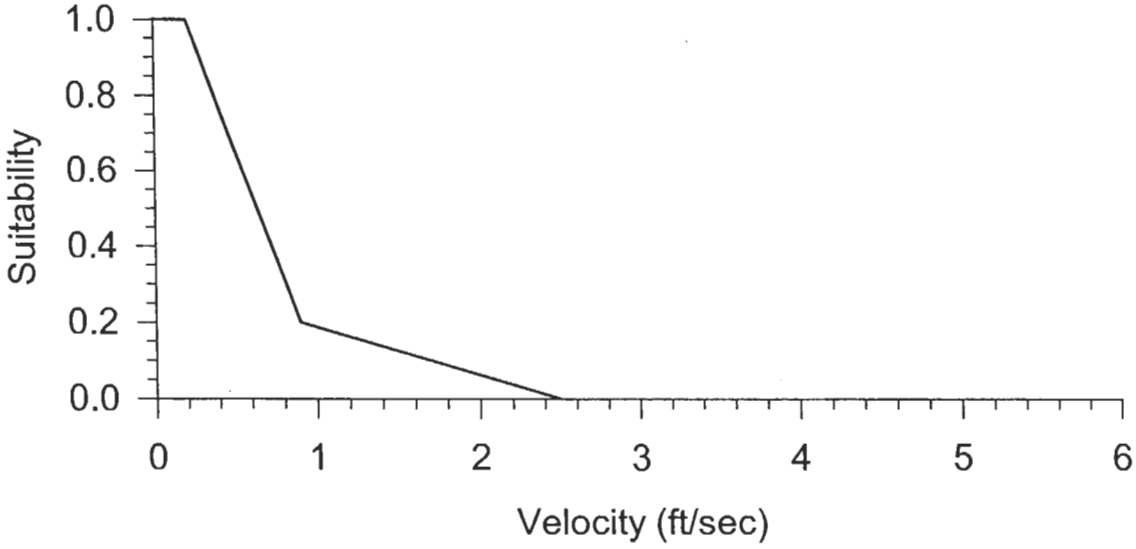


Figure C-5. Habitat suitability criteria for coho salmon spawning.





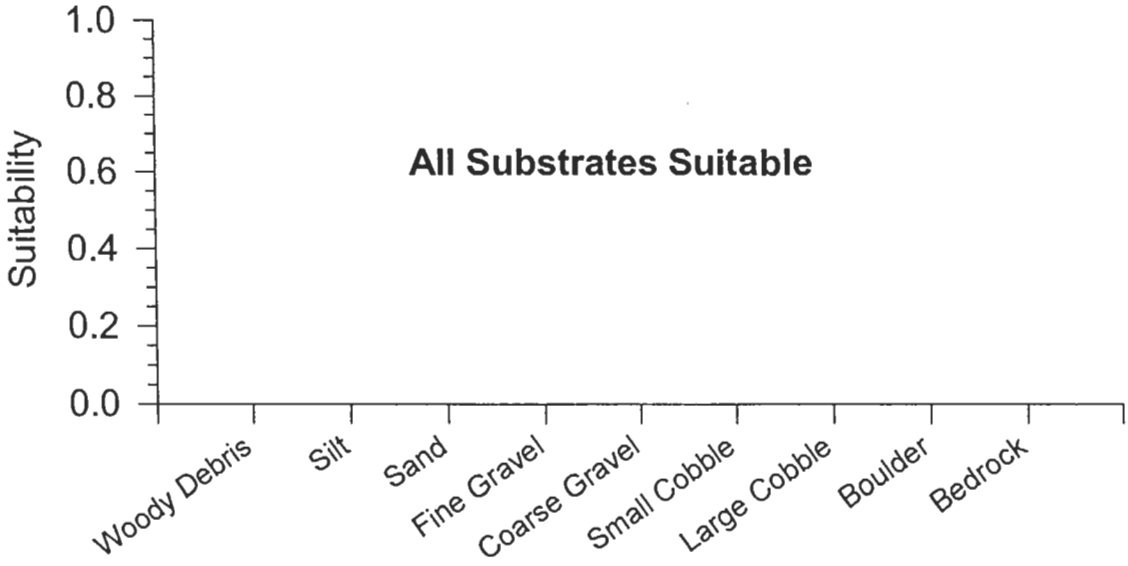
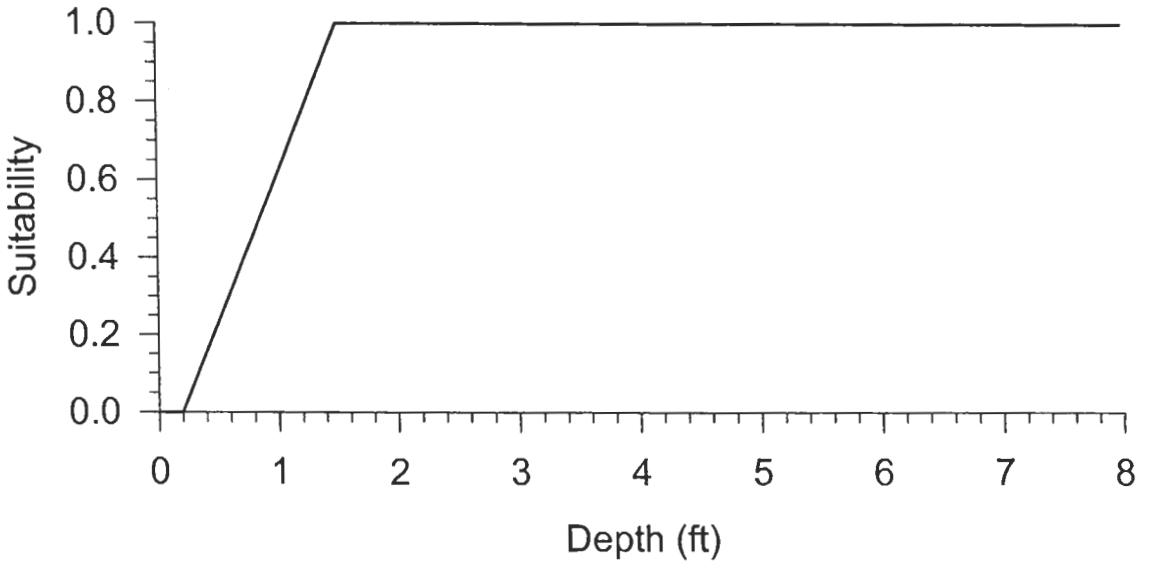
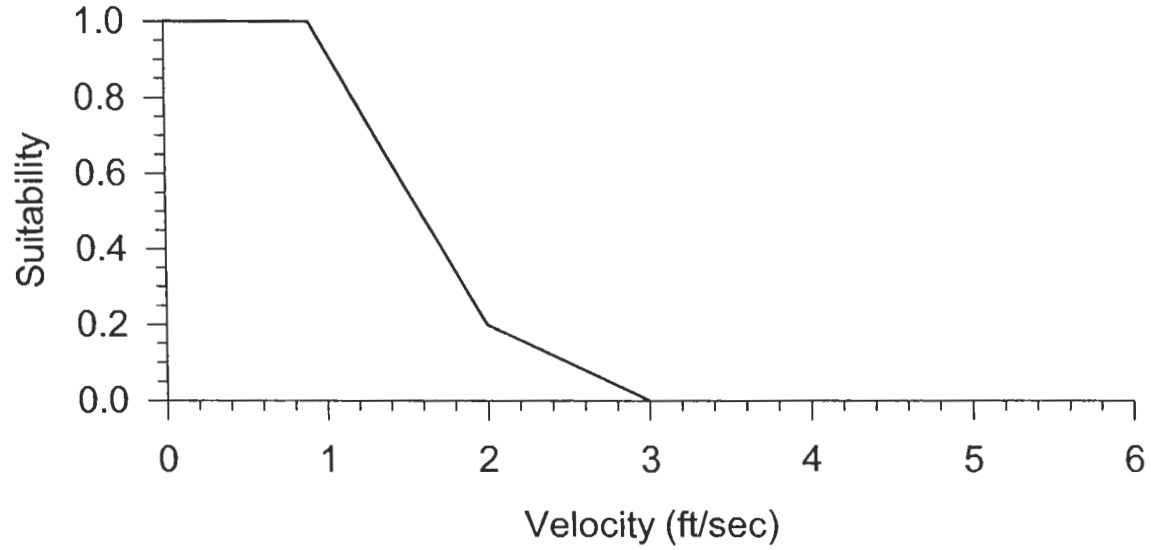


Figure C-6. Habitat suitability criteria for coho salmon fry.





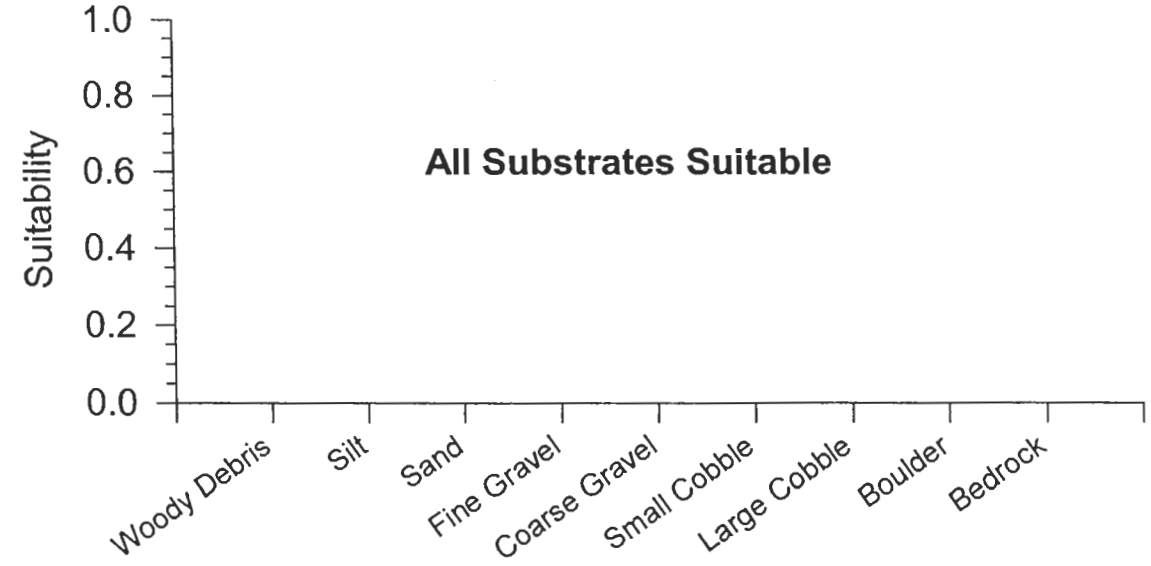


Figure C-7. Habitat suitability criteria for coho salmon juveniles.

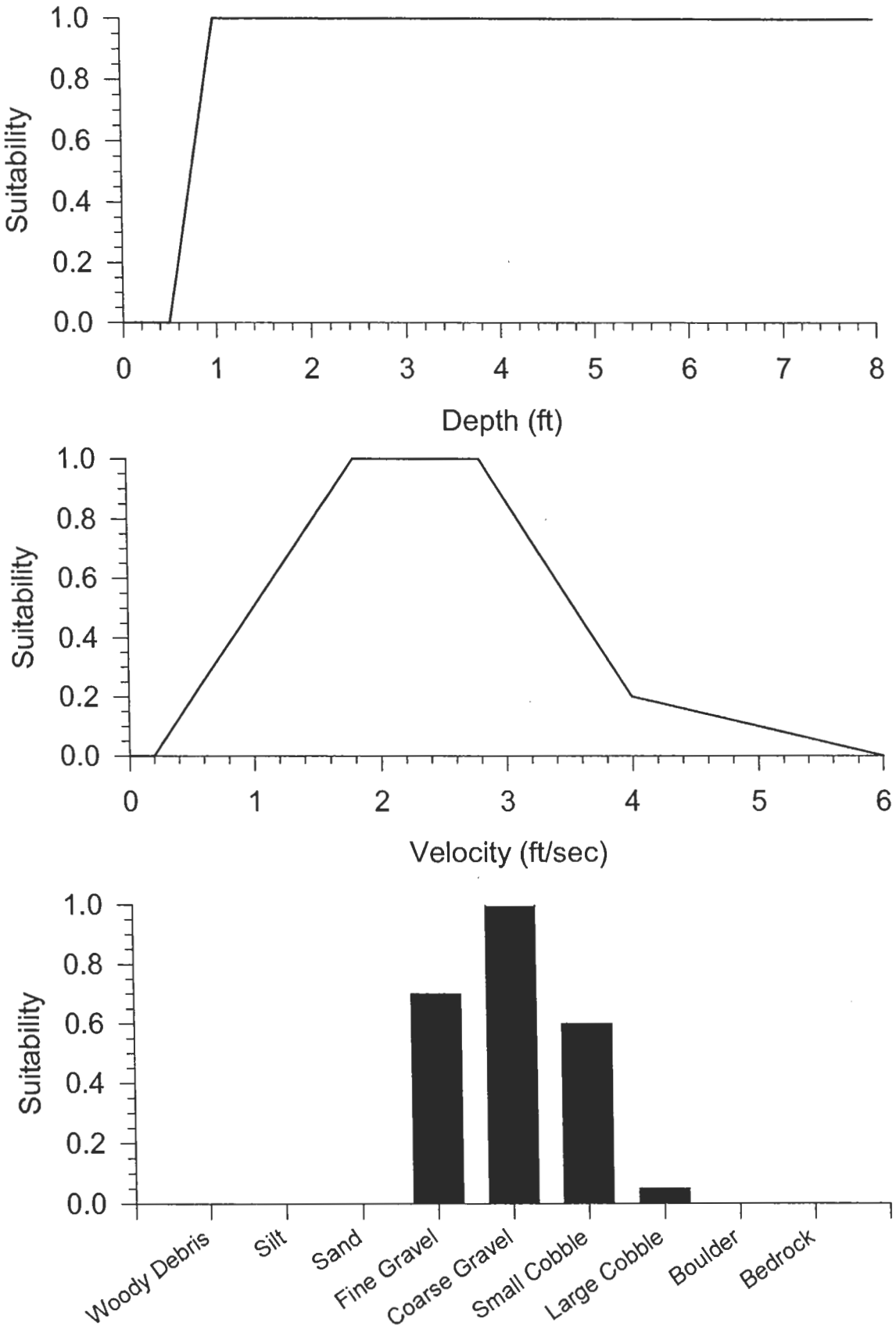


Figure C-8. Habitat suitability criteria for steelhead trout spawning.

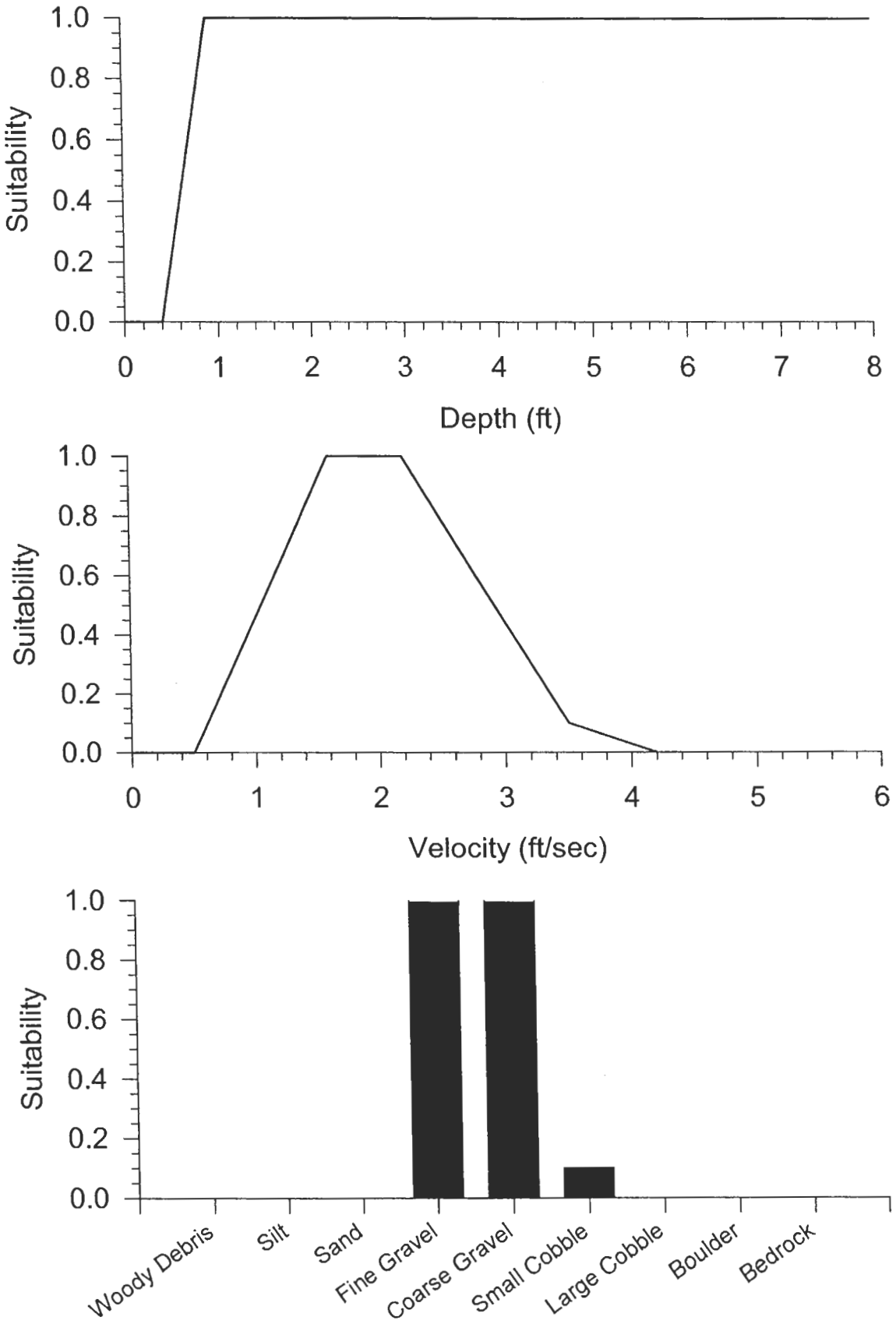
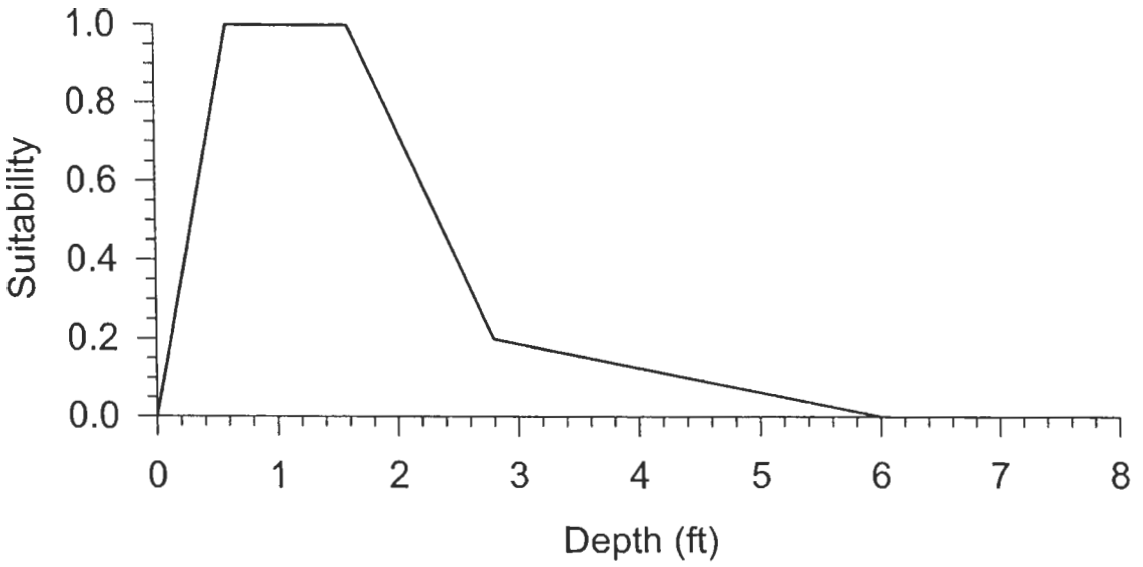
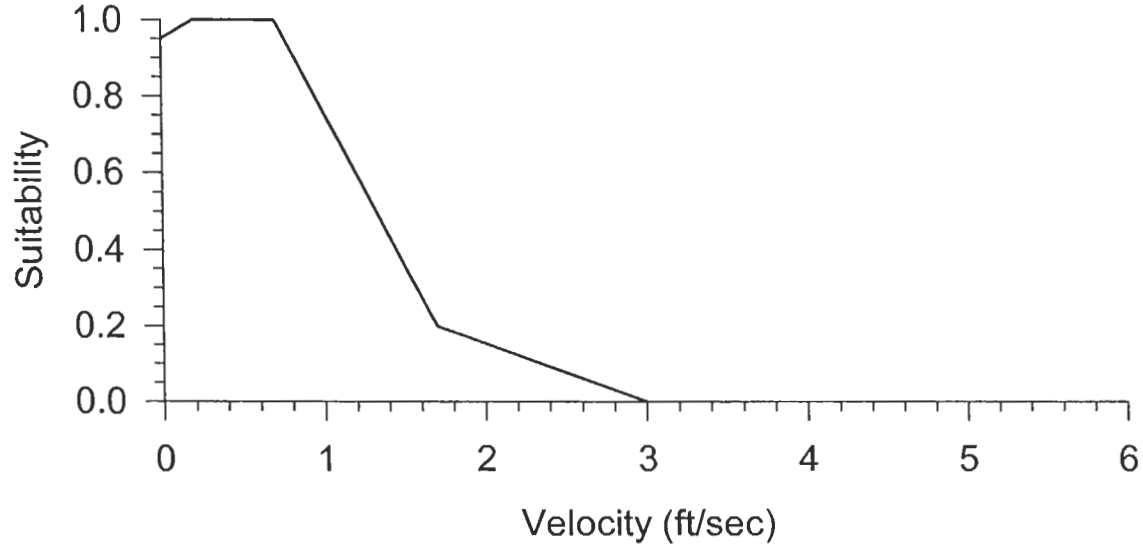


Figure C-9. Habitat suitability criteria for rainbow trout spawning.





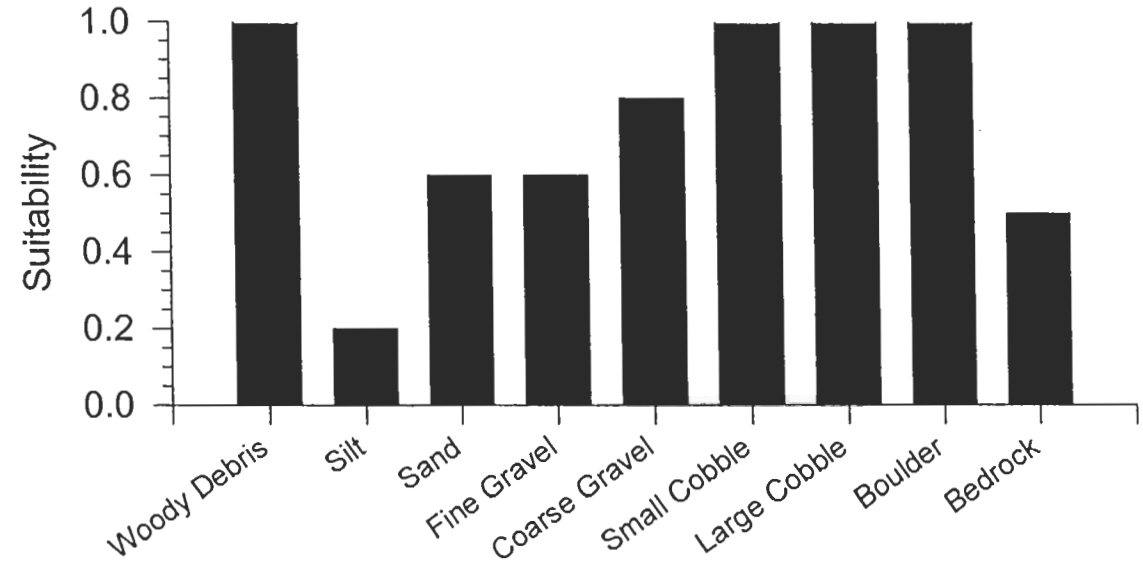
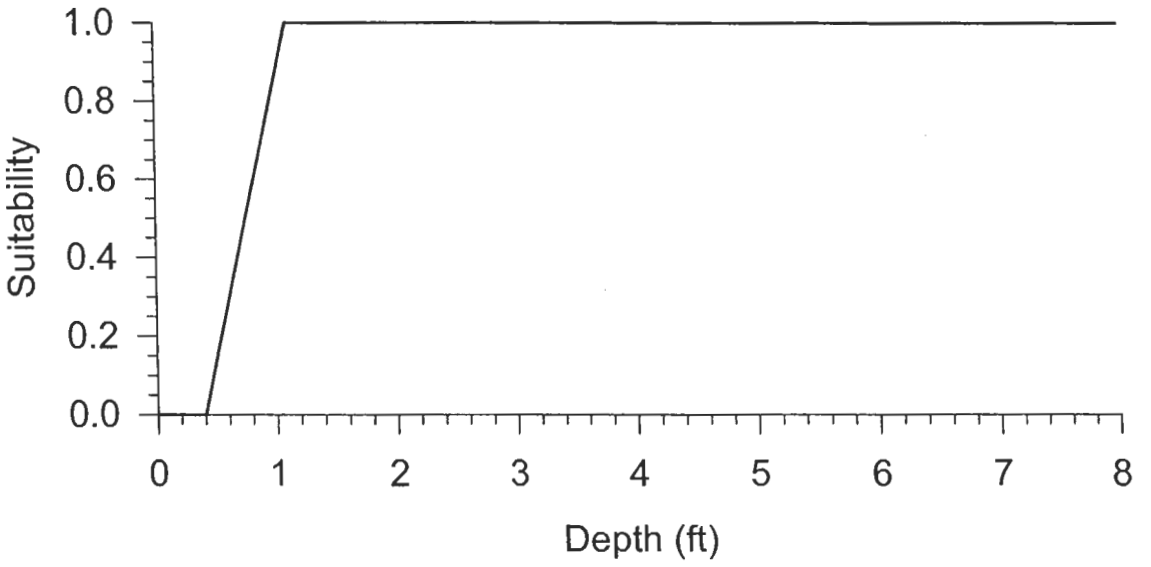
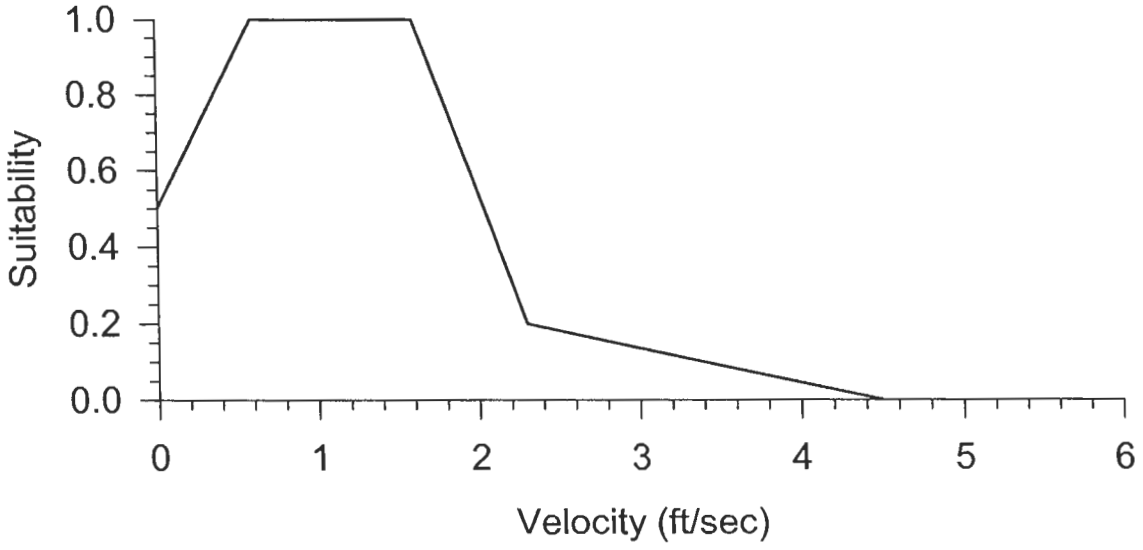


Figure C-10. Habitat suitability criteria for rainbow / steelhead trout fry.





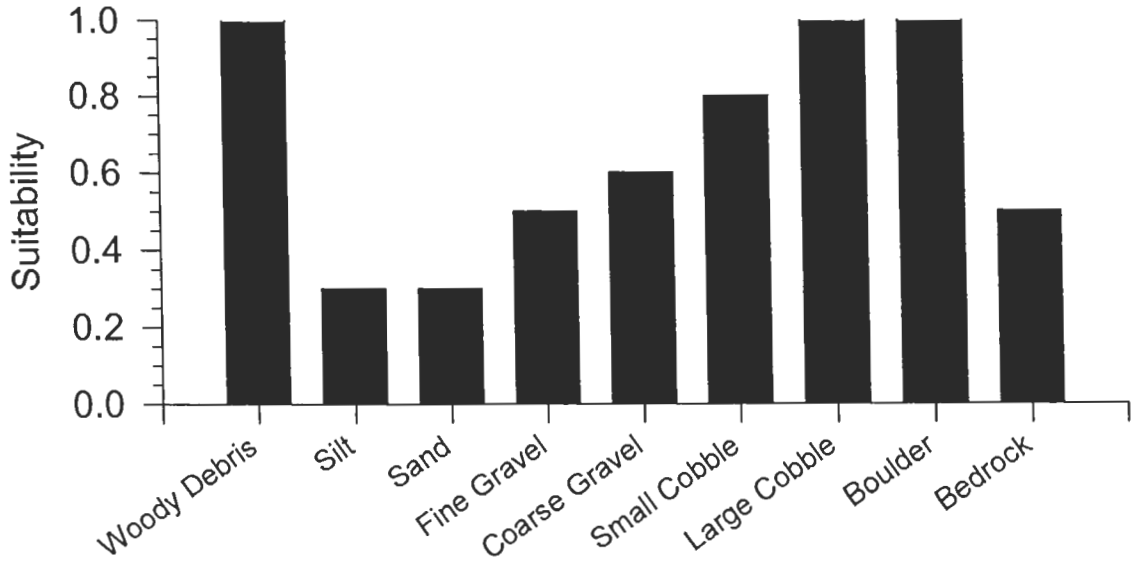


Figure C-11. Habitat suitability criteria for rainbow / steelhead trout juveniles.

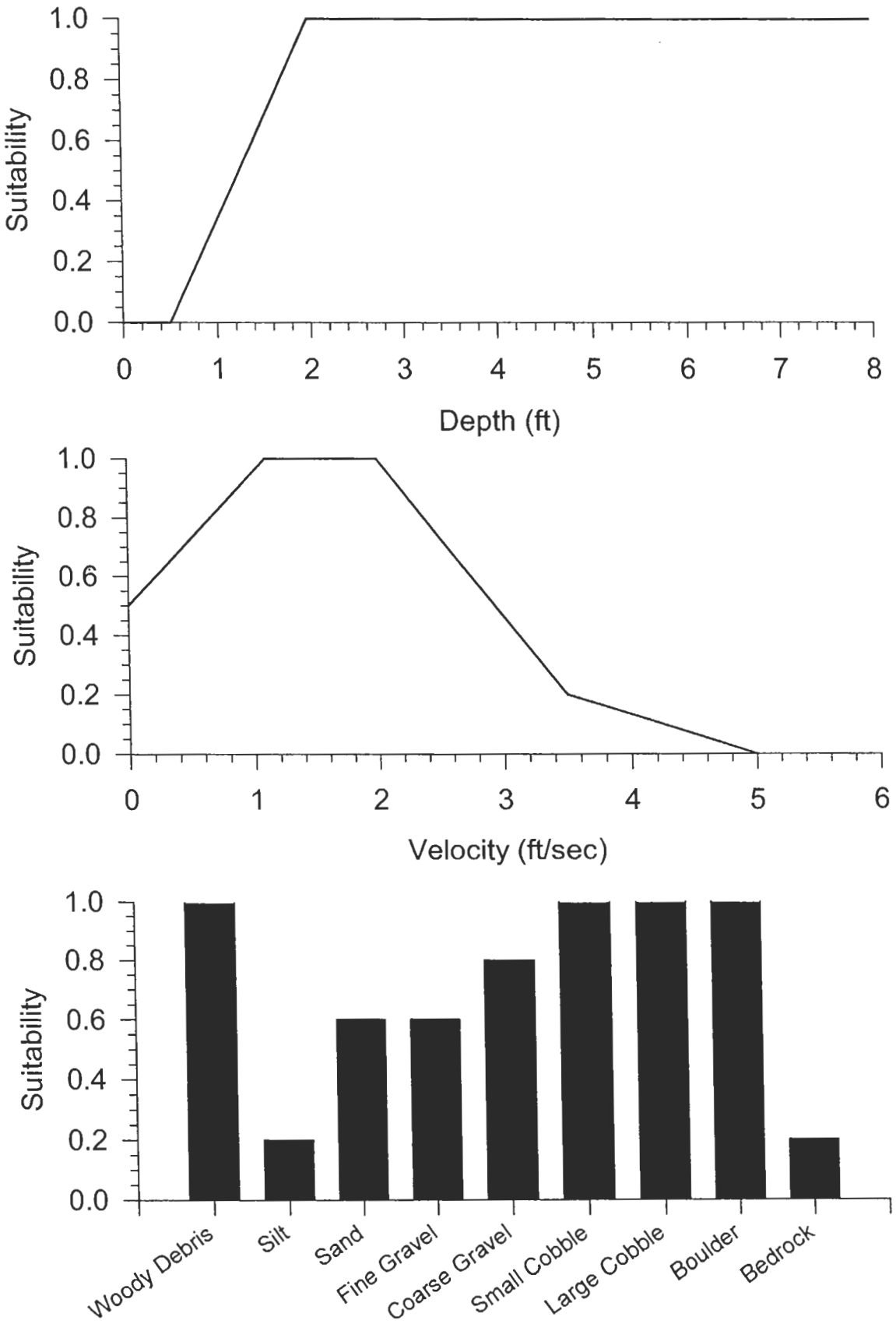


Figure C-12. Habitat suitability criteria for rainbow trout adults.

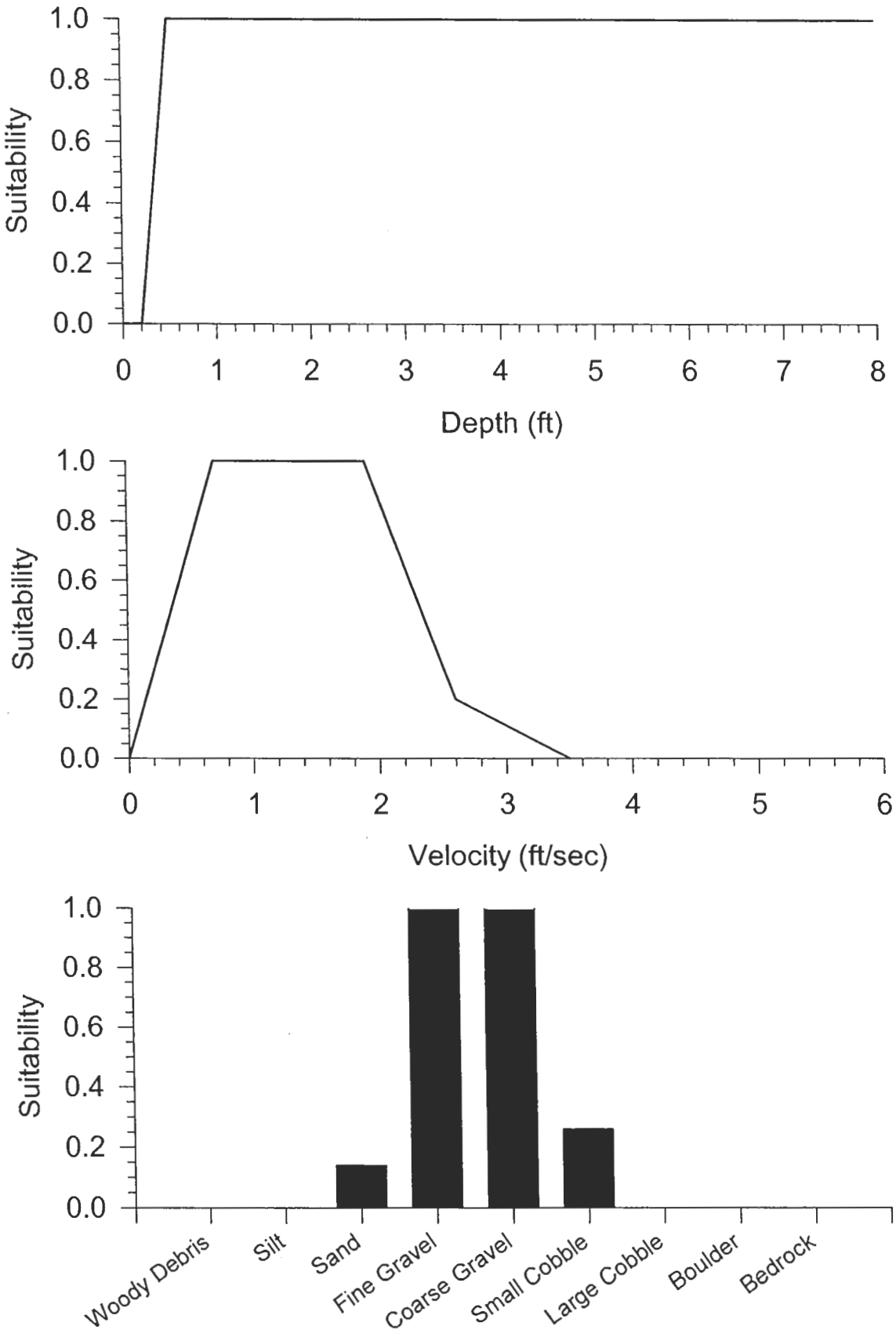
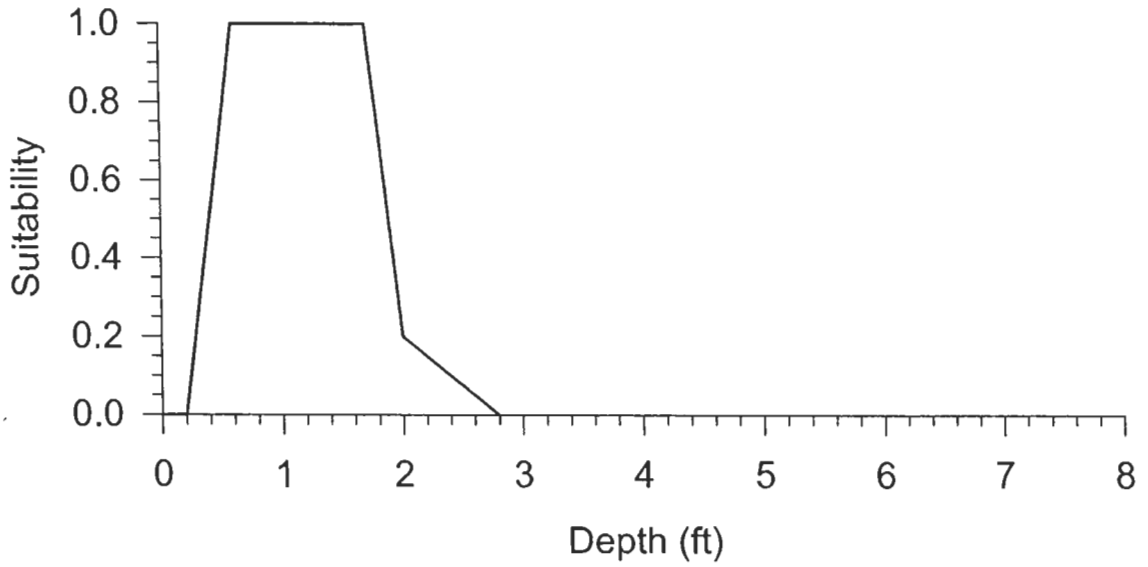
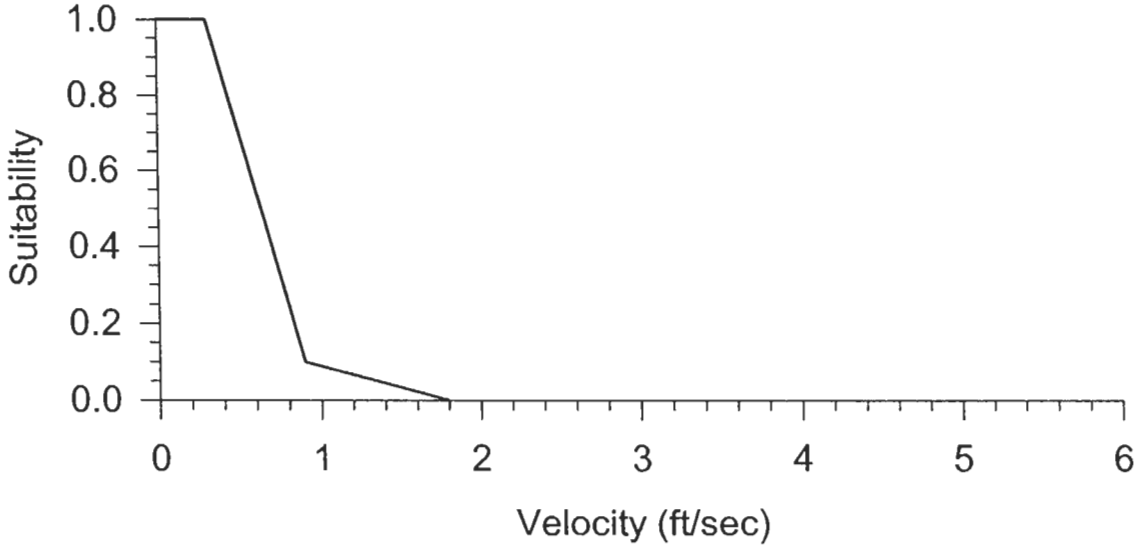


Figure C-13. Habitat suitability criteria for bull trout spawning.





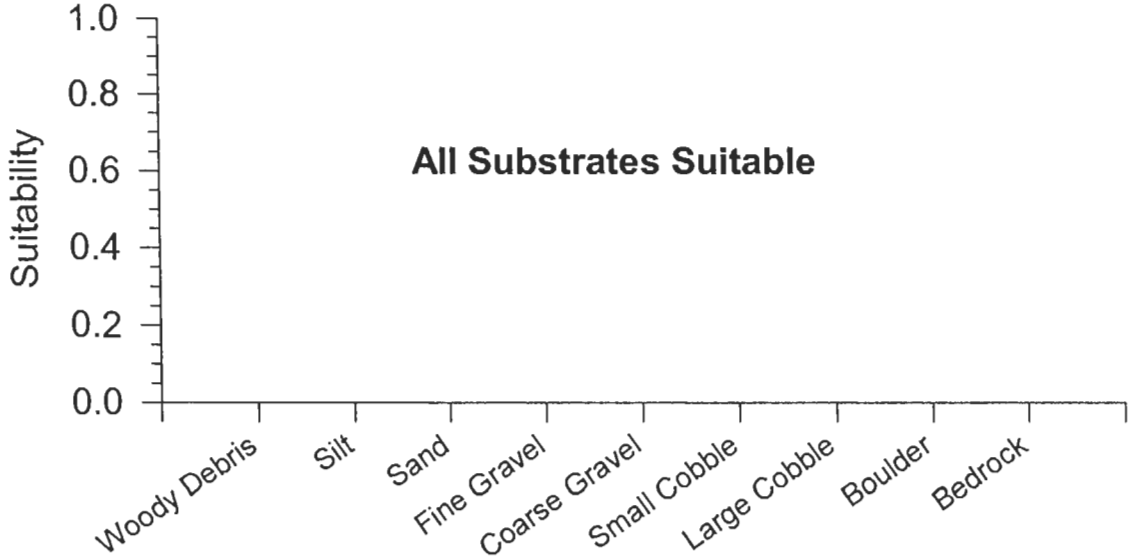
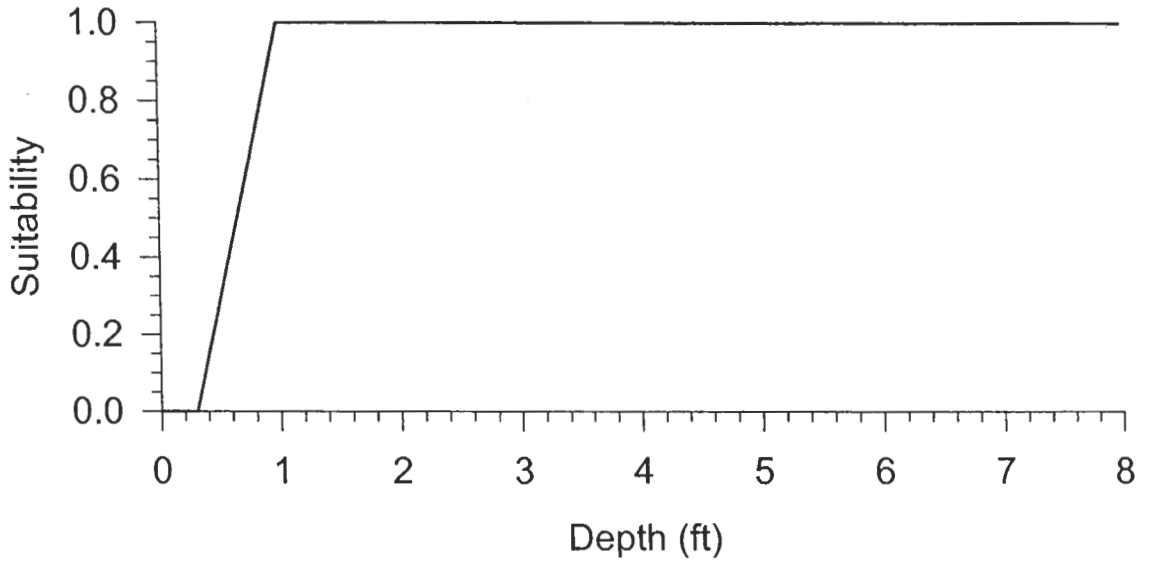
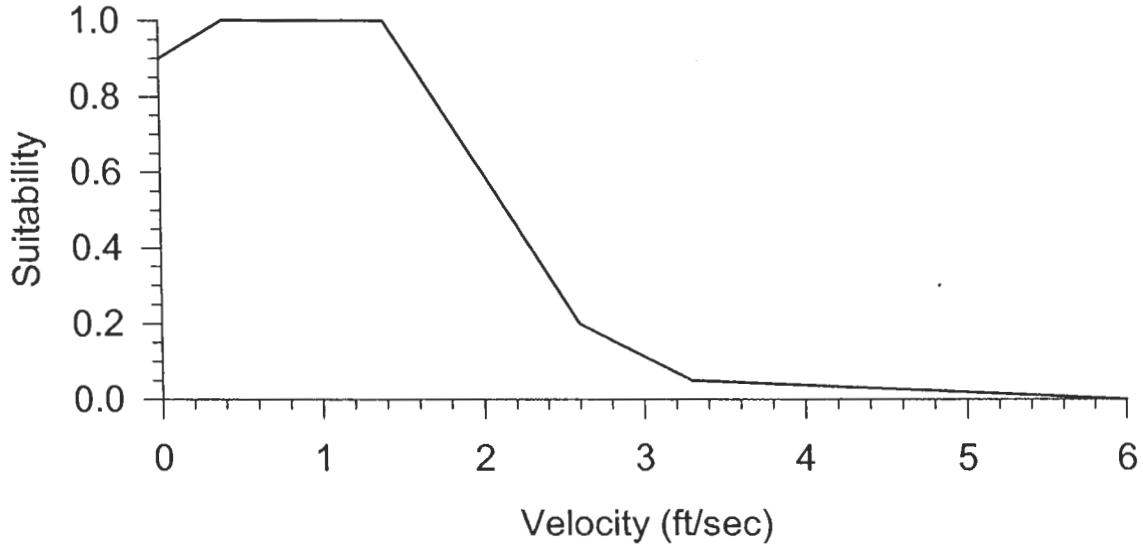


Figure C-14. Habitat suitability criteria for bull trout fry.





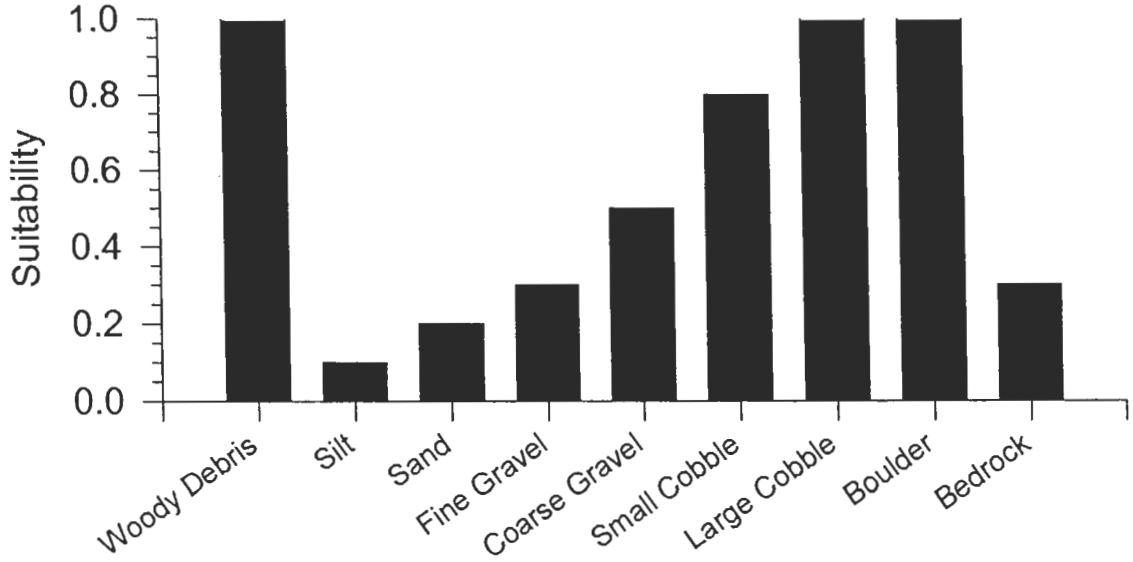
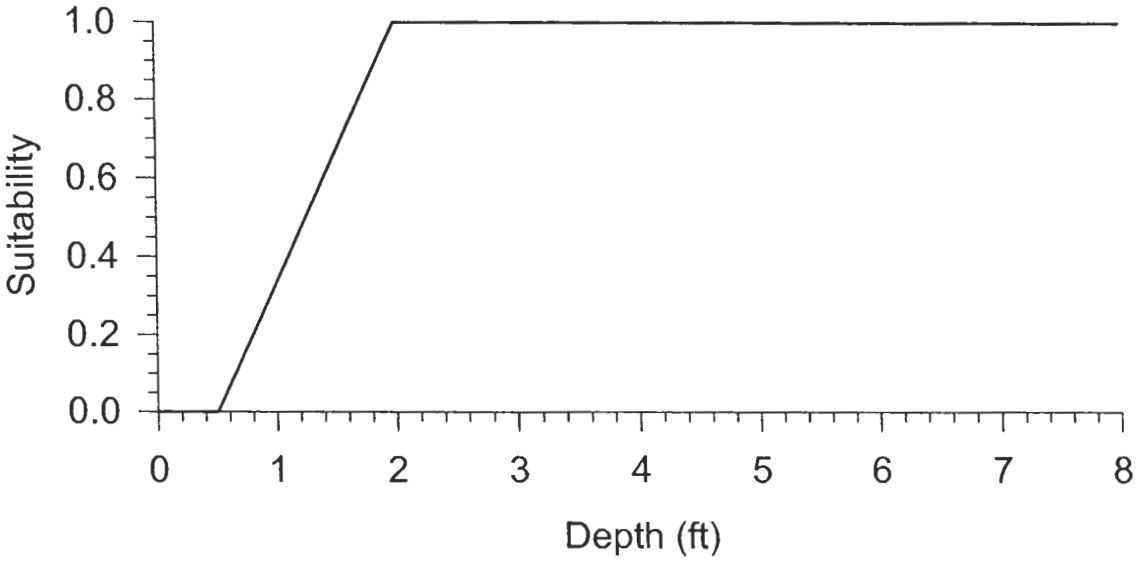
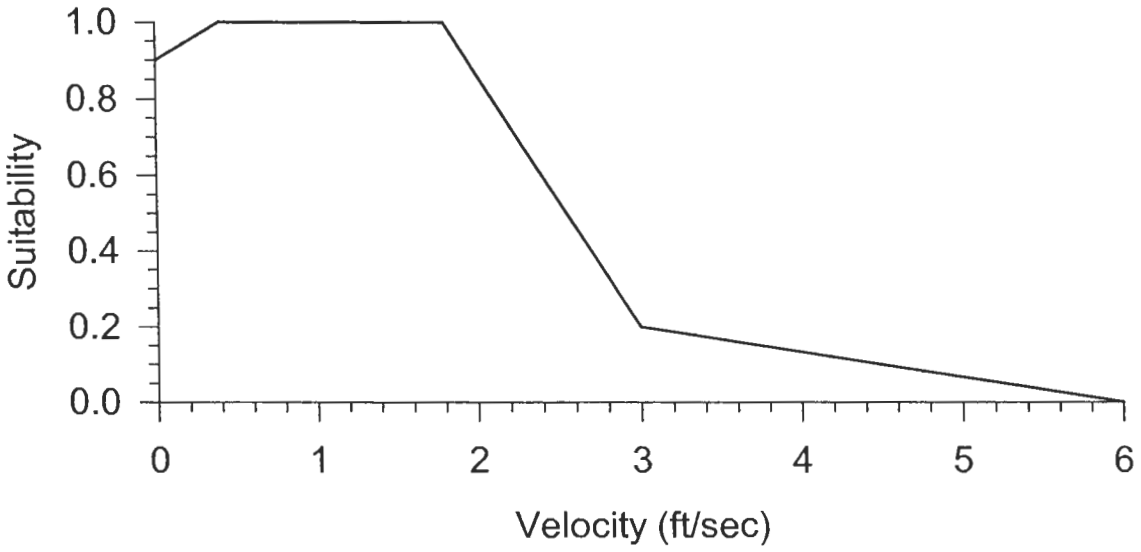


Figure C-15. Habitat suitability criteria for bull trout juveniles.





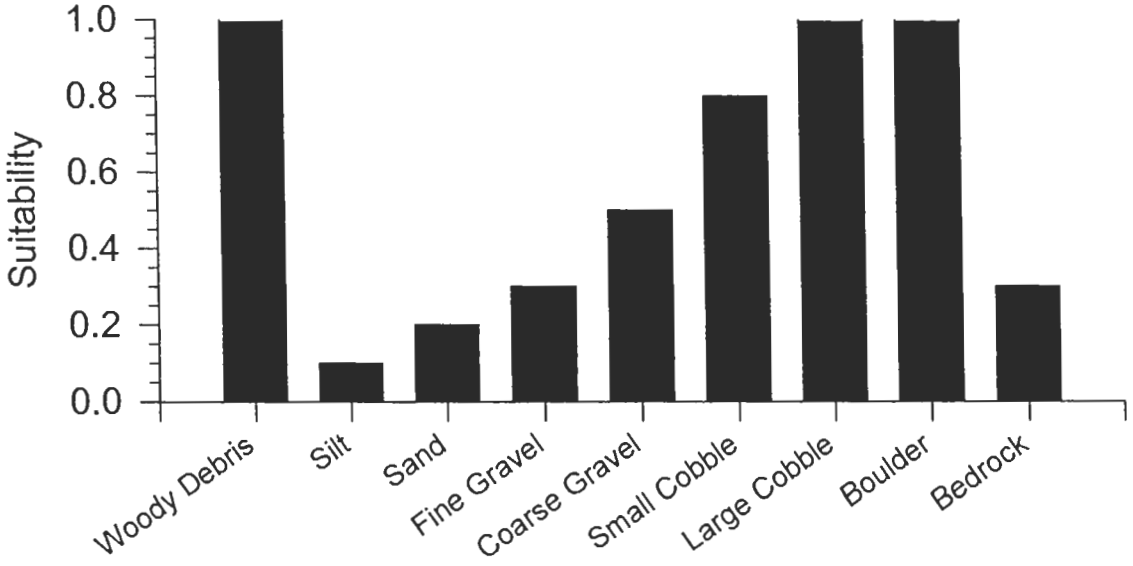


Figure C-16. Habitat suitability criteria for bull trout adults.

APPENDIX D

Weighted Usable Area (WUA) and Total Habitat Area (HA) Versus Flow Relationships for Reach 1

Table D-1. Spring chinook salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)				Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3	Site 4		
5	75	0	57	0	0.02	0.4
10	403	157	350	114	0.16	3.1
15	936	586	828	232	0.38	7.6
20	1,685	1,236	1,280	498	0.69	13.9
25	2,690	1,926	1,651	903	1.08	21.6
30	3,710	2,629	2,062	1,326	1.48	29.5
35	4,803	3,236	2,340	1,846	1.88	37.6
40	5,991	3,753	2,623	2,277	2.28	45.5
45	6,960	4,017	2,921	2,973	2.67	53.2
50	7,974	4,207	3,182	3,553	3.03	60.4
55	8,859	4,351	3,394	4,001	3.32	66.3
60	9,637	4,568	3,604	4,558	3.63	72.4
65	10,416	4,785	3,814	5,115	3.94	78.5
70	11,121	4,869	3,941	5,365	4.14	82.7
75	11,679	4,952	4,047	5,727	4.34	86.6
80	12,086	5,036	4,125	6,170	4.53	90.3
85	12,440	5,088	4,160	6,445	4.66	92.9
90	12,826	5,159	4,235	6,680	4.80	95.7
95	12,986	5,212	4,243	6,853	4.87	97.1
100	13,142	5,210	4,257	6,952	4.92	98.1
110	13,173	5,210	4,343	7,281	5.00	99.8
120	13,120	5,192	4,367	7,382	5.01	100.0
130	12,869	5,148	4,386	7,425	4.97	99.2
140	12,674	5,040	4,382	7,318	4.90	97.8
150	12,238	4,891	4,350	7,231	4.78	95.4
160	11,746	4,842	4,384	7,291	4.70	93.8
170	11,380	4,705	4,353	7,131	4.58	91.4
180	10,925	4,608	4,294	7,175	4.49	89.6
190	10,474	4,419	4,213	6,965	4.33	86.5
200	9,910	4,258	4,165	7,016	4.22	84.1
250	8,450	3,390	3,730	8,263	4.05	80.9
300	6,990	2,522	3,296	9,509	3.89	77.7
350	6,031	1,960	3,108	10,479	3.83	76.5
400	5,159	1,649	2,750	10,666	3.63	72.5
450	4,663	1,461	2,475	10,523	3.46	69.0
500	4,468	1,344	2,253	10,106	3.30	65.8
600	4,006	1,271	2,099	8,610	2.88	57.5
700	3,297	1,346	2,350	7,219	2.50	49.9
800	2,606	1,235	2,265	5,823	2.07	41.3
900	2,064	955	1,941	4,582	1.65	32.9
1,000	1,632	762	1,542	3,499	1.28	25.5

Table D-2. Fall chinook salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)				Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3	Site 4		
5	0	4	10	0	0.00	0.0
10	2	48	151	38	0.03	0.5
15	122	253	466	125	0.13	2.0
20	425	828	914	415	0.36	5.6
25	928	1,537	1,409	736	0.65	10.1
30	1,456	2,408	1,953	1,006	0.95	15.0
35	2,180	3,336	2,524	1,417	1.34	20.9
40	3,139	4,533	3,119	1,882	1.80	28.3
45	4,125	5,466	3,633	2,734	2.32	36.3
50	5,352	6,045	4,096	3,605	2.84	44.5
55	6,486	6,403	4,500	4,284	3.27	51.3
60	7,626	6,803	5,032	5,252	3.79	59.4
65	8,765	7,203	5,564	6,220	4.30	67.5
70	9,984	7,472	5,784	6,607	4.66	73.1
75	11,102	7,734	6,041	7,105	5.03	78.9
80	12,085	7,841	6,213	7,697	5.37	84.2
85	12,965	7,902	6,254	8,019	5.61	88.0
90	13,960	7,966	6,346	8,401	5.89	92.4
95	14,454	8,026	6,280	8,652	6.04	94.7
100	15,075	7,998	6,223	8,798	6.17	96.8
110	15,773	7,911	6,206	9,102	6.35	99.7
120	16,050	7,719	6,082	9,121	6.38	100.0
130	15,891	7,519	6,053	9,229	6.34	99.5
140	16,001	7,245	6,100	9,066	6.31	99.0
150	15,779	6,885	6,073	8,901	6.19	97.1
160	15,489	6,665	6,165	8,777	6.10	95.7
170	15,265	6,354	6,144	8,197	5.91	92.7
180	14,826	6,102	6,229	7,791	5.73	89.8
190	14,340	5,821	6,322	7,119	5.48	86.0
200	13,666	5,649	6,518	6,837	5.30	83.2
250	11,847	5,062	5,839	8,136	5.09	79.8
300	10,027	4,475	5,159	9,435	4.87	76.4
350	9,103	3,821	4,456	11,002	4.86	76.3
400	8,126	3,077	3,835	12,327	4.80	75.3
450	7,310	2,415	3,752	12,833	4.67	73.3
500	6,884	1,868	3,682	12,880	4.54	71.2
600	6,035	1,497	3,154	11,154	3.93	61.6
700	5,142	1,560	2,619	8,541	3.17	49.8
800	4,019	1,701	2,597	6,062	2.47	38.7
900	3,053	1,299	2,280	4,258	1.84	28.9
1,000	2,430	936	1,935	3,327	1.46	22.9

Table D-3. Chinook salmon fry weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	2,099	3,789	6,883	2,186	2.04	52.9
10	3,313	6,013	8,278	3,345	2.89	75.1
15	4,169	7,136	8,555	4,100	3.35	87.1
20	4,554	7,530	8,821	4,548	3.59	93.2
25	4,920	7,332	8,966	4,928	3.73	96.9
30	4,959	7,122	8,890	4,892	3.70	96.1
35	4,927	6,966	8,827	4,938	3.68	95.6
40	4,970	7,076	8,946	4,892	3.70	96.2
45	4,745	6,894	8,929	5,566	3.78	98.2
50	4,678	6,645	9,040	6,034	3.85	100.0
55	4,603	6,395	9,017	6,173	3.84	99.6
60	4,531	6,283	8,362	5,297	3.55	92.3
65	4,458	6,170	7,707	4,422	3.27	85.1
70	4,511	5,967	7,570	4,041	3.17	82.3
75	4,502	5,753	7,497	3,900	3.11	80.8
80	4,467	5,491	7,422	4,017	3.09	80.3
85	4,454	5,231	7,376	3,933	3.04	79.0
90	4,463	4,989	7,413	3,924	3.02	78.4
95	4,365	4,873	7,301	3,916	2.97	77.3
100	4,340	4,718	7,199	3,823	2.92	75.9
110	4,154	4,514	7,185	3,829	2.87	74.5
120	4,080	4,323	7,071	3,792	2.81	73.1
130	3,951	4,097	6,943	3,848	2.76	71.7
140	3,947	3,855	6,871	3,884	2.73	71.0
150	3,872	3,614	6,750	3,947	2.69	70.0
160	3,801	3,376	6,707	4,159	2.69	70.0
170	3,716	3,128	6,608	4,267	2.66	69.2
180	3,621	2,980	6,586	4,463	2.67	69.3
190	3,457	2,794	6,517	4,525	2.62	68.1
200	3,246	2,599	6,569	4,656	2.60	67.4
250	2,368	1,834	3,817	3,272	1.75	45.4
300	1,491	1,068	1,064	1,889	0.90	23.3
350	1,306	744	868	1,729	0.78	20.1
400	1,055	497	805	1,625	0.67	17.5
450	859	354	739	1,493	0.59	15.3
500	722	270	685	1,330	0.51	13.4
600	528	184	522	877	0.36	9.3
700	572	129	413	785	0.33	8.5
800	693	118	463	663	0.33	8.6
900	714	100	556	776	0.37	9.6
1,000	739	224	471	865	0.39	10.2

Table D-4. Chinook salmon juvenile weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	380	1,327	2,947	664	0.69	16.5
10	1,012	3,831	4,715	1,609	1.46	35.0
15	1,658	6,233	6,014	2,167	2.10	50.2
20	2,338	8,022	7,246	2,886	2.70	64.6
25	3,047	8,734	8,137	3,747	3.18	76.2
30	3,567	9,067	8,303	4,139	3.41	81.8
35	4,002	8,982	8,434	4,595	3.60	86.1
40	4,502	9,214	8,723	4,699	3.77	90.3
45	4,617	8,965	8,965	5,600	3.98	95.2
50	4,752	8,638	9,411	6,258	4.16	99.5
55	4,798	8,171	9,608	6,433	4.18	100.0
60	4,853	7,997	9,074	6,144	4.05	96.9
65	4,908	7,822	8,541	5,855	3.92	93.8
70	4,961	7,657	8,572	5,526	3.85	92.1
75	4,916	7,531	8,636	5,484	3.82	91.6
80	4,773	7,381	8,597	5,674	3.82	91.4
85	4,726	7,267	8,589	5,521	3.76	90.2
90	4,785	7,113	8,656	5,353	3.73	89.4
95	4,760	7,021	8,548	5,174	3.67	87.9
100	4,923	6,771	8,472	4,958	3.62	86.7
110	5,077	6,335	8,506	4,660	3.55	85.0
120	5,235	6,010	8,454	4,248	3.46	82.8
130	5,234	5,771	8,488	3,974	3.38	81.0
140	5,396	5,538	8,600	3,810	3.37	80.6
150	5,393	5,406	8,603	3,796	3.35	80.2
160	5,368	5,285	8,721	3,918	3.37	80.8
170	5,375	5,116	8,669	3,857	3.34	79.9
180	5,452	5,018	8,714	3,972	3.37	80.7
190	5,418	4,768	8,668	3,923	3.32	79.6
200	5,292	4,485	8,770	4,040	3.31	79.2
250	3,780	3,020	5,494	3,552	2.39	57.2
300	2,268	1,556	2,217	3,064	1.47	35.2
350	1,962	1,207	1,770	2,393	1.19	28.4
400	1,848	991	1,256	2,117	1.03	24.6
450	1,687	772	934	2,029	0.92	22.0
500	1,470	572	890	1,925	0.83	19.9
600	1,098	340	756	1,788	0.69	16.6
700	915	256	595	1,497	0.57	13.7
800	790	162	485	1,379	0.50	12.0
900	761	114	471	1,060	0.43	10.2
1,000	935	87	526	805	0.41	9.8

Table D-5. Coho salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)				Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3	Site 4		
5	1,338	732	929	412	0.52	9.6
10	3,211	1,958	1,997	1,162	1.27	23.6
15	5,227	3,248	2,828	2,143	2.08	38.5
20	7,145	4,356	3,461	3,059	2.82	52.1
25	9,006	5,004	4,001	3,933	3.47	64.2
30	10,459	5,451	4,470	4,523	3.97	73.4
35	11,505	5,711	4,717	5,053	4.33	80.0
40	12,387	5,918	4,941	5,491	4.63	85.6
45	12,791	5,905	5,060	6,393	4.90	90.7
50	13,221	5,840	5,172	7,078	5.13	94.9
55	13,363	5,745	5,232	7,398	5.22	96.5
60	13,453	5,996	5,092	7,734	5.31	98.3
65	13,544	6,246	4,951	8,069	5.41	100.0
70	13,527	6,086	4,906	7,852	5.34	98.7
75	13,378	5,993	4,910	7,817	5.29	97.9
80	13,025	5,846	4,888	8,075	5.26	97.3
85	12,656	5,673	4,868	8,033	5.17	95.5
90	12,344	5,495	4,899	8,018	5.09	94.1
95	11,810	5,380	4,840	7,934	4.95	91.6
100	11,418	5,220	4,803	7,742	4.82	89.1
110	10,660	4,856	4,790	7,602	4.61	85.2
120	10,104	4,540	4,709	7,329	4.41	81.5
130	9,461	4,305	4,589	7,264	4.24	78.3
140	9,094	4,101	4,462	7,268	4.13	76.4
150	8,599	3,884	4,328	7,309	4.01	74.1
160	8,072	3,760	4,211	7,545	3.93	72.7
170	7,693	3,621	4,058	7,610	3.84	71.0
180	7,216	3,532	3,960	7,777	3.77	69.6
190	6,817	3,398	3,840	7,768	3.66	67.7
200	6,452	3,263	3,765	7,953	3.61	66.7
250	5,447	2,470	2,987	9,192	3.50	64.7
300	4,443	1,678	2,209	10,430	3.39	62.7
350	3,797	1,320	2,215	9,599	3.06	56.6
400	3,311	1,147	1,924	8,307	2.66	49.1
450	3,036	1,149	1,693	7,020	2.32	42.8
500	2,698	1,166	1,596	5,733	1.98	36.6
600	1,884	1,066	1,547	3,460	1.35	24.9
700	1,318	784	1,360	2,445	0.99	18.2
800	926	449	1,017	1,835	0.71	13.2
900	628	261	599	1,712	0.56	10.4
1,000	478	220	419	1,959	0.56	10.4

Table D-6. Coho salmon fry weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	5,925	6,375	8,655	5,688	3.94	95.4
10	6,252	6,595	8,521	5,883	4.05	98.0
15	6,244	6,529	7,956	5,942	3.99	96.5
20	5,939	6,470	7,974	5,963	3.93	95.1
25	5,872	6,465	8,044	6,157	3.96	95.9
30	5,690	6,478	8,008	6,061	3.91	94.6
35	5,635	6,346	7,882	6,067	3.87	93.7
40	5,701	6,435	7,902	5,940	3.87	93.6
45	5,623	6,399	7,817	6,582	3.97	96.1
50	5,671	6,315	7,885	7,240	4.11	99.5
55	5,641	6,051	7,867	7,504	4.13	100.0
60	5,418	5,731	7,352	6,417	3.77	91.4
65	5,194	5,411	6,838	5,331	3.42	82.7
70	5,118	5,224	6,752	5,127	3.33	80.7
75	4,957	5,024	6,632	5,076	3.26	78.9
80	4,761	4,754	6,418	5,271	3.21	77.7
85	4,585	4,491	6,241	5,336	3.14	76.0
90	4,438	4,272	6,145	5,443	3.10	75.1
95	4,219	4,109	6,016	5,485	3.04	73.5
100	4,080	3,900	5,908	5,486	2.98	72.1
110	3,788	3,564	5,810	5,580	2.90	70.1
120	3,569	3,285	5,626	5,581	2.80	67.9
130	3,340	3,019	5,477	5,611	2.72	65.9
140	3,182	2,751	5,350	5,528	2.63	63.8
150	2,971	2,497	5,208	5,483	2.54	61.5
160	2,823	2,320	5,146	5,533	2.50	60.5
170	2,699	2,154	4,996	5,486	2.43	58.9
180	2,595	2,071	4,905	5,516	2.40	58.1
190	2,495	1,982	4,788	5,443	2.34	56.7
200	2,391	1,898	4,739	5,440	2.31	55.9
250	1,749	1,365	2,956	3,772	1.58	38.3
300	1,107	833	1,174	2,104	0.86	20.8
350	925	563	1,229	1,977	0.78	18.8
400	799	431	1,110	1,718	0.67	16.3
450	760	370	952	1,399	0.58	14.0
500	732	320	824	1,207	0.51	12.4
600	738	280	729	1,184	0.49	12.0
700	961	344	917	1,184	0.56	13.7
800	969	425	1,016	1,280	0.61	14.7
900	822	589	819	1,133	0.54	13.1
1,000	778	935	868	1,436	0.64	15.4

Table D-7. Coho salmon juvenile weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	2,052	3,469	6,929	2,099	1.98	35.9
10	3,619	6,219	8,708	3,686	3.09	55.9
15	4,910	8,203	9,655	4,901	3.89	70.4
20	5,801	9,496	10,580	5,747	4.47	80.9
25	6,592	10,094	11,196	6,549	4.92	89.0
30	6,953	10,501	11,435	6,748	5.10	92.2
35	7,186	10,647	11,482	6,904	5.19	93.9
40	7,464	11,061	11,588	6,850	5.29	95.7
45	7,358	10,996	11,442	7,723	5.42	98.1
50	7,395	10,723	11,454	8,340	5.53	100.0
55	7,366	10,180	11,366	8,495	5.49	99.3
60	7,242	9,847	10,930	8,204	5.32	96.3
65	7,118	9,514	10,494	7,914	5.15	93.2
70	7,123	9,246	10,295	7,416	5.00	90.5
75	7,052	9,051	10,189	7,247	4.92	89.0
80	6,905	8,772	10,011	7,488	4.89	88.5
85	6,806	8,512	9,885	7,325	4.80	86.8
90	6,802	8,197	9,877	7,256	4.75	86.0
95	6,636	8,035	9,712	7,086	4.65	84.1
100	6,565	7,743	9,575	6,879	4.55	82.3
110	6,249	7,314	9,542	6,626	4.39	79.4
120	6,006	6,976	9,407	6,317	4.23	76.6
130	5,725	6,596	9,304	6,110	4.09	73.9
140	5,678	6,205	9,305	5,826	3.98	72.0
150	5,612	5,893	9,264	5,600	3.89	70.3
160	5,554	5,691	9,337	5,568	3.86	69.8
170	5,532	5,456	9,280	5,423	3.79	68.6
180	5,520	5,312	9,343	5,475	3.79	68.6
190	5,458	5,045	9,319	5,391	3.73	67.6
200	5,304	4,800	9,441	5,487	3.71	67.2
250	3,975	3,396	5,864	4,794	2.76	49.9
300	2,647	1,993	2,287	4,101	1.80	32.6
350	2,399	1,455	1,839	3,548	1.54	27.8
400	2,147	1,074	1,540	2,877	1.28	23.2
450	1,876	833	1,362	2,462	1.10	19.9
500	1,619	628	1,297	2,245	0.98	17.7
600	1,193	389	1,080	1,943	0.79	14.2
700	936	224	813	1,634	0.63	11.3
800	922	173	722	1,280	0.54	9.7
900	994	166	827	1,362	0.58	10.5
1,000	1,027	225	861	1,505	0.62	11.3

Table D-8. Steelhead trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	2	8	57	6	0.01	0.1
10	114	87	229	46	0.07	1.0
15	403	401	471	193	0.21	3.2
20	771	823	822	381	0.40	6.1
25	1,281	1,327	1,217	674	0.66	10.0
30	1,933	1,965	1,629	993	0.96	14.5
35	2,765	2,571	2,036	1,376	1.30	19.8
40	3,725	3,313	2,439	1,779	1.69	25.6
45	4,596	3,961	2,780	2,460	2.10	31.8
50	5,584	4,393	3,094	3,139	2.50	38.0
55	6,568	4,735	3,403	3,666	2.86	43.5
60	7,702	5,121	3,977	4,472	3.35	50.8
65	8,835	5,508	4,550	5,277	3.83	58.2
70	9,933	5,768	4,819	5,702	4.18	63.5
75	10,913	5,981	5,038	6,229	4.52	68.7
80	11,805	6,129	5,245	6,784	4.84	73.5
85	12,662	6,222	5,382	7,165	5.11	77.5
90	13,473	6,333	5,556	7,549	5.37	81.5
95	14,047	6,452	5,648	7,897	5.57	84.6
100	14,721	6,534	5,742	8,136	5.77	87.6
110	15,653	6,722	5,959	8,765	6.11	92.8
120	16,329	6,877	6,071	9,178	6.35	96.5
130	16,410	6,985	6,125	9,604	6.47	98.3
140	16,604	7,032	6,138	9,945	6.58	100.0
150	16,472	6,950	6,102	10,088	6.58	99.9
160	16,231	6,917	6,109	10,246	6.56	99.6
170	16,051	6,790	6,026	10,131	6.48	98.4
180	15,792	6,723	6,009	10,197	6.44	97.8
190	15,456	6,530	5,990	9,943	6.30	95.7
200	15,016	6,382	6,084	9,971	6.22	94.4
250	13,546	5,561	6,127	10,385	5.95	90.3
300	12,076	4,740	6,171	10,799	5.68	86.2
350	10,551	4,080	5,734	12,134	5.54	84.2
400	9,131	3,507	5,120	13,048	5.33	81.0
450	8,173	3,001	4,588	13,160	5.06	76.9
500	7,676	2,590	4,114	12,934	4.82	73.3
600	6,978	2,136	3,583	12,214	4.44	67.4
700	6,093	1,956	3,576	11,308	4.07	61.8
800	5,129	1,968	3,503	9,856	3.58	54.4
900	4,301	1,747	3,221	8,310	3.06	46.4
1,000	3,731	1,468	2,932	6,799	2.58	39.2

Table D-9. Rainbow trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	11	0	7	0	0.00	0.1
10	63	72	45	15	0.03	1.0
15	139	263	106	42	0.07	2.7
20	275	525	176	90	0.14	5.3
25	489	830	239	161	0.24	8.7
30	728	1,169	310	240	0.34	12.5
35	979	1,470	363	337	0.45	16.3
40	1,264	1,701	416	438	0.55	20.1
45	1,588	1,801	477	574	0.65	24.0
50	1,943	1,906	531	698	0.76	28.0
55	2,297	2,011	580	805	0.87	31.8
60	2,624	2,142	664	1,016	1.00	36.5
65	2,951	2,273	749	1,228	1.12	41.2
70	3,283	2,308	786	1,353	1.22	44.7
75	3,587	2,343	819	1,499	1.31	48.2
80	3,801	2,378	854	1,651	1.39	51.0
85	4,005	2,406	882	1,781	1.46	53.7
90	4,242	2,445	916	1,900	1.54	56.5
95	4,399	2,485	943	2,015	1.60	58.7
100	4,516	2,510	970	2,097	1.65	60.3
110	4,706	2,585	1,023	2,340	1.74	63.9
120	4,876	2,672	1,057	2,543	1.83	67.1
130	4,977	2,751	1,084	2,735	1.90	69.6
140	5,077	2,830	1,098	2,915	1.97	72.0
150	5,091	2,882	1,100	3,134	2.02	73.9
160	5,047	2,963	1,108	3,442	2.08	76.3
170	5,016	3,019	1,099	3,648	2.12	77.8
180	4,852	3,105	1,101	3,943	2.16	79.2
190	4,658	3,167	1,080	4,158	2.17	79.6
200	4,373	3,228	1,065	4,482	2.19	80.2
250	4,144	2,591	1,061	5,926	2.37	87.0
300	3,916	1,955	1,058	7,371	2.56	93.8
350	3,605	1,282	1,081	8,814	2.73	100.0
400	2,921	912	1,029	9,118	2.62	96.0
450	2,259	877	987	8,811	2.42	88.8
500	2,150	864	1,015	8,643	2.37	86.9
600	2,104	1,074	1,289	8,112	2.31	84.5
700	1,949	1,283	1,720	7,895	2.31	84.5
800	1,820	1,436	1,820	7,861	2.30	84.4
900	1,716	1,251	1,836	7,803	2.25	82.6
1,000	1,485	1,178	1,797	7,194	2.07	76.0

Table D-10. Rainbow trout fry weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	12,486	13,222	13,169	12,858	7.86	68.8
10	16,386	18,293	16,412	16,011	10.14	88.7
15	18,450	20,032	17,042	17,369	11.05	96.7
20	19,120	19,983	17,515	17,691	11.29	98.8
25	19,660	19,178	17,490	18,269	11.43	100.0
30	19,396	18,379	16,816	17,726	11.11	97.2
35	18,856	17,328	16,087	17,145	10.69	93.6
40	18,359	17,018	15,783	16,143	10.33	90.4
45	17,221	16,411	15,340	16,855	10.15	88.8
50	16,527	15,820	15,337	17,349	10.06	88.0
55	15,734	15,063	15,154	17,097	9.76	85.4
60	15,344	14,568	14,518	15,752	9.28	81.2
65	14,954	14,074	13,882	14,408	8.81	77.1
70	14,625	13,583	13,678	13,788	8.55	74.8
75	14,044	13,133	13,541	13,653	8.35	73.1
80	13,486	12,637	13,296	13,982	8.23	72.1
85	13,028	12,172	13,013	13,808	8.03	70.3
90	12,628	11,720	12,863	13,673	7.87	68.8
95	12,155	11,391	12,504	13,476	7.66	67.0
100	11,969	10,945	12,161	13,224	7.49	65.5
110	11,416	10,160	11,746	13,002	7.21	63.1
120	10,779	9,493	11,356	12,584	6.89	60.3
130	10,178	8,886	11,006	12,369	6.63	58.0
140	9,724	8,278	10,792	12,151	6.42	56.1
150	9,219	7,750	10,575	12,019	6.21	54.4
160	8,788	7,305	10,480	12,148	6.10	53.4
170	8,441	6,818	10,266	12,087	5.95	52.1
180	8,186	6,392	10,100	12,214	5.87	51.3
190	7,870	5,915	9,849	12,132	5.71	50.0
200	7,505	5,473	9,751	12,246	5.61	49.1
250	5,282	3,758	6,177	8,993	3.93	34.4
300	3,059	2,043	2,602	5,740	2.26	19.8
350	2,666	1,701	2,176	4,128	1.77	15.5
400	2,345	1,335	2,051	3,377	1.51	13.2
450	1,939	1,043	1,953	2,982	1.31	11.4
500	1,572	868	1,804	2,682	1.14	10.0
600	1,239	581	1,291	2,359	0.92	8.1
700	1,023	448	956	2,235	0.81	7.0
800	913	425	867	2,428	0.81	7.1
900	796	427	944	2,754	0.86	7.6
1,000	706	498	778	2,938	0.87	7.6

Table D-11. Rainbow trout juvenile weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	416	1,316	2,387	878	0.67	8.2
10	1,187	4,253	3,921	2,374	1.60	19.5
15	2,204	7,537	5,602	3,743	2.60	31.7
20	3,457	10,602	7,521	5,409	3.72	45.3
25	4,882	12,918	9,354	7,215	4.80	58.5
30	6,000	14,975	10,794	8,302	5.61	68.4
35	6,800	16,531	11,842	9,322	6.25	76.2
40	7,692	18,175	12,753	9,892	6.81	83.0
45	8,090	18,917	13,114	11,636	7.36	89.7
50	8,816	18,952	13,532	12,875	7.80	95.1
55	9,365	18,328	13,475	13,411	7.94	96.8
60	9,837	17,531	13,376	14,078	8.08	98.4
65	10,309	16,734	13,276	14,744	8.21	100.0
70	10,679	16,010	12,997	14,071	8.03	97.9
75	10,849	15,412	12,907	13,880	7.95	96.9
80	10,860	14,740	12,656	14,185	7.92	96.5
85	10,895	14,184	12,572	13,852	7.79	95.0
90	11,058	13,720	12,648	13,516	7.72	94.0
95	10,934	13,516	12,423	13,079	7.56	92.1
100	11,009	13,199	12,201	12,585	7.41	90.3
110	10,827	12,740	12,100	12,081	7.22	87.9
120	10,687	12,281	11,943	11,361	6.98	85.0
130	10,276	11,781	11,905	10,904	6.75	82.3
140	10,121	11,387	11,874	10,341	6.57	80.0
150	9,742	10,976	11,764	9,869	6.34	77.3
160	9,504	10,611	11,747	9,629	6.21	75.7
170	9,436	10,152	11,526	9,105	6.02	73.3
180	9,499	9,946	11,493	8,903	5.96	72.7
190	9,498	9,601	11,399	8,488	5.83	71.1
200	9,439	9,316	11,450	8,329	5.77	70.3
250	7,854	7,025	8,184	8,114	4.81	58.6
300	6,268	4,735	4,918	7,898	3.85	46.9
350	4,972	3,274	4,306	7,558	3.31	40.4
400	4,055	2,304	3,542	6,804	2.80	34.1
450	3,519	1,777	2,900	5,644	2.33	28.4
500	3,124	1,552	2,413	4,367	1.92	23.4
600	2,540	1,199	1,944	3,064	1.45	17.7
700	2,027	844	1,656	2,632	1.20	14.6
800	1,649	592	1,185	2,558	1.03	12.6
900	1,540	448	962	2,498	0.96	11.7
1,000	1,469	357	897	2,434	0.91	11.1

Table D-12. Rainbow trout adult weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	202	320	1,137	96	0.22	3.7
10	297	1,045	1,481	469	0.43	7.2
15	539	2,213	1,974	996	0.76	12.7
20	854	3,475	2,669	1,503	1.13	18.9
25	1,314	4,583	3,437	2,212	1.57	26.1
30	1,846	5,677	4,126	2,823	1.99	33.1
35	2,395	6,630	4,788	3,479	2.40	39.9
40	2,987	7,753	5,457	4,059	2.82	47.0
45	3,429	8,641	6,033	5,088	3.27	54.5
50	3,952	9,383	6,666	5,981	3.70	61.6
55	4,390	9,917	7,150	6,594	4.02	66.9
60	4,881	10,462	7,745	7,586	4.44	73.9
65	5,373	11,008	8,341	8,579	4.86	80.9
70	5,835	11,382	8,637	8,794	5.06	84.3
75	6,150	11,692	8,898	9,229	5.27	87.8
80	6,443	11,861	9,043	9,904	5.50	91.6
85	6,708	11,967	9,174	10,206	5.64	93.9
90	6,985	11,975	9,388	10,495	5.77	96.1
95	7,130	12,097	9,366	10,635	5.84	97.2
100	7,409	12,045	9,311	10,683	5.89	98.1
110	7,707	11,932	9,422	10,859	5.98	99.6
120	7,997	11,834	9,343	10,793	6.01	100.0
130	8,056	11,567	9,293	10,753	5.98	99.5
140	8,289	11,162	9,240	10,536	5.93	98.7
150	8,283	10,836	9,141	10,348	5.84	97.3
160	8,289	10,580	9,219	10,342	5.83	97.0
170	8,327	10,257	9,089	9,990	5.71	95.1
180	8,342	10,124	9,100	9,857	5.68	94.5
190	8,248	9,760	9,034	9,379	5.52	91.9
200	8,040	9,445	9,206	9,253	5.44	90.6
250	7,661	7,975	8,348	8,587	4.98	83.0
300	7,282	6,504	7,490	7,921	4.53	75.4
350	6,736	5,352	6,735	7,393	4.11	68.4
400	6,235	4,422	5,605	7,025	3.71	61.8
450	5,896	3,604	4,733	6,821	3.42	57.0
500	5,606	2,927	4,084	6,573	3.17	52.8
600	4,930	2,134	3,232	6,229	2.79	46.5
700	4,285	1,581	2,570	5,602	2.41	40.1
800	3,599	1,090	2,119	4,864	2.03	33.8
900	2,973	891	1,657	4,134	1.69	28.1
1,000	2,564	805	1,398	3,600	1.46	24.3

Table D-13. Bull trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	1,363	958	809	236	0.50	13.9
10	2,986	2,320	1,404	740	1.11	31.0
15	4,577	2,884	1,803	1,429	1.66	46.2
20	5,964	3,132	2,014	2,078	2.10	58.6
25	7,213	3,273	2,176	2,565	2.47	68.8
30	7,939	3,426	2,345	2,812	2.69	75.0
35	8,378	3,582	2,419	3,050	2.85	79.3
40	8,690	3,717	2,533	3,266	2.98	82.9
45	8,773	3,798	2,610	3,739	3.10	86.5
50	8,871	3,883	2,677	4,090	3.21	89.5
55	8,864	3,821	2,728	4,342	3.26	90.9
60	8,979	4,039	2,780	4,898	3.42	95.4
65	9,095	4,258	2,833	5,454	3.59	100.0
70	8,863	4,328	2,854	5,449	3.55	99.0
75	8,592	4,332	2,894	5,532	3.52	98.2
80	8,279	4,311	2,878	5,737	3.50	97.6
85	8,002	4,234	2,832	5,767	3.44	96.0
90	7,793	4,081	2,802	5,901	3.41	95.1
95	7,509	3,950	2,731	5,963	3.35	93.4
100	7,294	3,789	2,680	5,926	3.28	91.4
110	6,746	3,448	2,623	6,175	3.19	88.8
120	6,276	3,141	2,562	6,279	3.08	85.8
130	5,747	2,899	2,507	6,670	3.03	84.4
140	5,468	2,690	2,442	7,094	3.03	84.6
150	5,136	2,448	2,364	7,468	3.01	84.0
160	4,838	2,285	2,287	7,979	3.04	84.6
170	4,634	2,118	2,187	8,239	3.02	84.2
180	4,343	1,988	2,128	8,403	2.98	83.1
190	4,130	1,817	2,065	8,390	2.91	81.2
200	3,963	1,669	2,048	8,529	2.89	80.6
250	3,445	1,379	1,680	8,870	2.79	77.8
300	2,926	1,090	1,311	9,211	2.69	75.0
350	2,691	1,061	1,348	9,008	2.61	72.6
400	2,522	1,078	1,535	8,386	2.47	68.9
450	2,153	1,187	1,706	7,183	2.19	61.0
500	1,816	1,139	1,979	5,766	1.86	52.0
600	1,202	1,120	1,981	3,259	1.24	34.5
700	765	796	1,756	2,019	0.84	23.5
800	482	398	1,156	1,324	0.54	15.0
900	255	194	618	1,044	0.35	9.8
1,000	162	149	394	1,138	0.32	9.0

Table D-14. Bull trout fry weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)				Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3	Site 4		
5	2,773	4,676	6,506	2,897	2.35	88.4
10	3,349	5,362	6,275	3,523	2.63	98.8
15	3,643	4,881	5,524	4,080	2.66	100.0
20	3,371	4,316	5,422	4,135	2.55	95.9
25	3,043	3,917	5,384	4,192	2.46	92.3
30	2,723	3,841	5,104	4,050	2.33	87.4
35	2,605	3,684	4,714	3,941	2.22	83.5
40	2,646	3,656	4,684	3,712	2.18	81.7
45	2,679	3,496	4,607	4,145	2.25	84.3
50	2,795	3,391	4,766	4,469	2.34	87.9
55	2,915	3,264	4,885	4,515	2.37	89.2
60	2,831	3,111	4,447	2,874	1.96	73.5
65	2,747	2,958	4,010	1,233	1.54	57.9
70	2,752	2,876	3,993	1,078	1.50	56.3
75	2,663	2,759	4,021	994	1.46	54.7
80	2,590	2,613	4,080	1,091	1.46	54.7
85	2,528	2,494	4,138	1,213	1.46	55.0
90	2,405	2,437	4,250	1,437	1.49	56.1
95	2,273	2,461	4,292	1,709	1.53	57.5
100	2,211	2,401	4,276	1,884	1.55	58.1
110	2,086	2,269	4,312	2,408	1.62	60.9
120	1,992	2,082	4,205	2,834	1.66	62.3
130	1,868	1,822	4,078	3,279	1.68	63.3
140	1,764	1,536	4,028	3,546	1.68	63.3
150	1,616	1,240	3,964	3,811	1.67	62.8
160	1,548	1,013	3,936	4,235	1.72	64.6
170	1,499	819	3,822	4,533	1.74	65.3
180	1,457	708	3,723	4,864	1.77	66.6
190	1,371	652	3,554	4,990	1.76	66.0
200	1,271	592	3,490	5,158	1.76	66.1
250	776	380	1,871	2,850	0.98	37.0
300	280	167	252	543	0.21	7.9
350	216	118	305	286	0.15	5.5
400	165	110	276	229	0.12	4.6
450	123	112	311	167	0.11	4.0
500	147	103	293	174	0.11	4.1
600	206	70	134	387	0.14	5.3
700	636	110	114	402	0.23	8.5
800	922	122	269	265	0.27	10.2
900	725	188	434	437	0.30	11.1
1,000	734	488	450	583	0.36	13.5

Table D-15. Bull trout juvenile weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	1,353	2,886	3,815	2,144	1.43	14.0
10	2,890	6,788	6,169	4,200	2.82	27.4
15	4,821	10,604	8,203	6,540	4.28	41.7
20	6,647	13,658	10,343	8,732	5.64	54.9
25	8,380	15,969	12,111	10,855	6.84	66.6
30	9,741	17,806	13,473	12,014	7.68	74.8
35	10,839	18,841	14,437	13,010	8.30	80.9
40	11,884	20,199	15,370	13,450	8.84	86.1
45	12,271	20,671	15,739	15,153	9.35	91.1
50	12,951	20,638	16,159	16,487	9.80	95.4
55	13,289	20,042	16,205	17,004	9.91	96.5
60	13,695	19,513	16,141	17,812	10.09	98.3
65	14,100	18,985	16,077	18,620	10.27	100.0
70	14,468	18,532	15,870	17,900	10.12	98.6
75	14,563	18,154	15,699	17,647	10.03	97.7
80	14,542	17,575	15,268	17,850	9.96	97.0
85	14,500	16,973	14,871	17,424	9.75	95.0
90	14,515	16,336	14,682	17,079	9.60	93.5
95	14,167	15,934	14,247	16,550	9.33	90.9
100	14,104	15,317	13,887	15,820	9.07	88.3
110	13,676	14,330	13,643	15,030	8.70	84.7
120	13,295	13,583	13,262	13,984	8.29	80.8
130	12,753	12,932	13,004	13,245	7.94	77.4
140	12,545	12,309	12,803	12,513	7.67	74.7
150	12,151	11,757	12,533	11,954	7.39	72.0
160	11,775	11,343	12,389	11,679	7.21	70.2
170	11,432	10,937	12,073	11,087	6.94	67.6
180	11,087	10,632	11,918	10,827	6.77	66.0
190	10,710	10,162	11,730	10,305	6.53	63.6
200	10,340	9,708	11,753	10,164	6.39	62.2
250	8,477	7,428	8,579	9,408	5.28	51.4
300	6,615	5,147	5,405	8,653	4.17	40.6
350	5,701	3,746	4,511	8,214	3.66	35.6
400	4,965	2,815	3,660	7,621	3.20	31.2
450	4,380	2,189	3,041	6,827	2.79	27.2
500	3,820	1,724	2,636	5,812	2.39	23.2
600	2,956	1,261	2,070	3,934	1.73	16.8
700	2,324	973	1,666	2,993	1.34	13.1
800	1,810	663	1,355	2,465	1.07	10.4
900	1,415	453	1,028	2,136	0.87	8.5
1,000	1,279	352	910	2,428	0.88	8.5

Table D-16. Bull trout adult weighted usable area and total habitat area versus discharge relationships for Reach 1; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Site 4	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	332	493	2,113	111	0.38	7.7
10	424	1,271	2,465	490	0.60	12.0
15	665	2,443	2,935	1,018	0.93	18.6
20	972	3,674	3,613	1,510	1.29	25.9
25	1,410	4,721	4,346	2,225	1.71	34.3
30	1,884	5,761	5,004	2,816	2.10	42.2
35	2,360	6,642	5,625	3,409	2.48	49.7
40	2,891	7,693	6,234	3,874	2.85	57.2
45	3,243	8,504	6,679	4,841	3.25	65.1
50	3,666	9,130	7,169	5,671	3.62	72.6
55	4,019	9,467	7,490	6,203	3.86	77.5
60	4,366	9,735	7,853	7,037	4.17	83.6
65	4,713	10,002	8,217	7,871	4.47	89.7
70	5,074	10,176	8,347	7,932	4.59	92.0
75	5,324	10,300	8,450	8,212	4.72	94.6
80	5,537	10,282	8,432	8,744	4.86	97.5
85	5,732	10,223	8,418	8,878	4.92	98.6
90	5,980	10,053	8,498	9,025	4.99	100.0
95	6,067	10,024	8,372	9,029	4.99	100.0
100	6,245	9,830	8,267	8,989	4.98	99.9
110	6,408	9,521	8,287	8,945	4.97	99.7
120	6,527	9,342	8,185	8,770	4.93	98.8
130	6,456	9,116	8,124	8,620	4.85	97.3
140	6,571	8,855	8,102	8,346	4.79	96.1
150	6,582	8,661	8,072	8,039	4.71	94.4
160	6,640	8,589	8,201	7,944	4.71	94.4
170	6,760	8,416	8,202	7,670	4.66	93.4
180	6,884	8,372	8,324	7,606	4.68	93.8
190	6,937	8,156	8,339	7,330	4.61	92.4
200	6,835	7,976	8,535	7,315	4.59	92.1
250	6,628	6,956	7,330	6,816	4.21	84.3
300	6,422	5,936	6,126	6,317	3.82	76.6
350	6,260	4,933	5,709	6,305	3.63	72.9
400	5,915	3,853	5,094	6,119	3.35	67.2
450	5,547	3,242	4,541	5,868	3.10	62.2
500	5,123	2,747	4,035	5,517	2.84	57.0
600	4,296	2,026	3,150	4,715	2.34	47.0
700	3,422	1,499	2,620	3,750	1.87	37.5
800	2,807	1,208	2,186	3,165	1.55	31.1
900	2,412	954	1,831	2,868	1.35	27.1
1,000	2,158	751	1,531	2,739	1.22	24.5

APPENDIX E

Weighted Usable Area (WUA) and Total Habitat Area (HA) Versus Flow Relationships for Reach 2

Table E-1. Spring chinook salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	0	0	0	0.00	0.0
10	37	0	0	0.01	0.3
15	103	3	0	0.02	0.8
20	162	21	0	0.03	1.3
25	206	51	0	0.04	1.8
30	216	87	0	0.05	2.0
35	243	130	0	0.06	2.3
40	251	176	0	0.06	2.6
45	263	227	0	0.07	2.8
50	277	257	0	0.08	3.1
55	294	281	0	0.08	3.3
60	382	287	57	0.11	4.4
65	469	294	113	0.14	5.5
70	509	294	160	0.15	6.1
75	553	294	206	0.17	6.8
80	605	294	241	0.18	7.4
85	661	294	276	0.20	8.1
90	721	294	311	0.22	8.8
95	789	294	334	0.23	9.5
100	874	294	369	0.26	10.4
110	1,038	294	406	0.29	11.9
120	1,240	282	405	0.33	13.4
130	1,552	262	412	0.39	15.7
140	1,896	243	401	0.45	18.2
150	2,297	225	362	0.52	20.8
160	2,662	205	324	0.58	23.3
170	3,122	189	301	0.66	26.5
180	3,560	170	284	0.73	29.6
190	3,995	153	268	0.81	32.8
200	4,394	138	276	0.89	35.8
250	5,643	178	1,682	1.37	55.5
300	6,892	217	3,087	1.86	75.3
350	6,891	1,089	4,174	2.14	86.4
400	6,349	2,221	5,343	2.35	94.9
450	5,706	3,440	6,090	2.47	100.0
500	4,947	4,294	6,379	2.46	99.5
600	3,513	4,044	6,611	2.21	89.4
700	2,674	2,940	6,479	1.93	78.0
800	2,022	1,916	5,662	1.57	63.3
900	1,497	987	4,453	1.17	47.1
1,000	1,389	152	3,276	0.86	34.7

Table E-2. Fall chinook salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	24	1	4	0.01	0.2
10	137	14	27	0.03	1.2
15	365	60	59	0.08	3.2
20	678	115	115	0.16	5.9
25	964	157	178	0.23	8.5
30	1,105	211	231	0.27	10.1
35	1,380	269	287	0.33	12.6
40	1,565	334	342	0.39	14.5
45	1,664	403	395	0.42	15.8
50	1,702	475	433	0.44	16.5
55	1,717	545	466	0.46	17.1
60	1,922	615	488	0.50	18.9
65	2,128	684	510	0.55	20.8
70	2,167	719	542	0.57	21.4
75	2,189	756	571	0.58	21.9
80	2,163	762	599	0.58	21.9
85	2,169	766	659	0.59	22.4
90	2,149	769	721	0.60	22.6
95	2,140	768	758	0.61	22.8
100	2,132	768	811	0.62	23.1
110	2,103	772	904	0.63	23.6
120	2,015	778	968	0.62	23.4
130	2,113	779	1,009	0.65	24.4
140	2,319	740	1,012	0.68	25.7
150	2,600	703	1,007	0.73	27.5
160	2,870	664	985	0.77	29.1
170	3,294	634	941	0.84	31.7
180	3,706	598	903	0.91	34.2
190	4,210	557	911	1.00	37.7
200	4,723	526	926	1.10	41.3
250	7,096	487	1,178	1.58	59.5
300	8,115	418	2,336	1.98	74.2
350	9,135	350	3,494	2.37	88.9
400	8,826	781	4,438	2.52	94.6
450	7,645	1,732	5,450	2.56	96.4
500	6,715	3,201	6,203	2.66	100.0
600	4,601	3,971	6,311	2.36	88.5
700	3,051	2,501	6,028	1.88	70.6
800	2,283	1,375	5,312	1.50	56.5
900	2,205	1,121	4,102	1.25	46.9
1,000	2,313	1,003	2,899	1.04	39.2

Table E-3. Chinook salmon fry weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	6,066	9,199	12,266	4.18	86.6
10	6,761	10,412	14,156	4.76	98.7
15	6,573	11,060	14,378	4.82	100.0
20	6,158	10,902	13,901	4.64	96.3
25	5,839	10,650	13,103	4.42	91.6
30	5,289	10,297	12,444	4.16	86.4
35	5,330	10,114	12,141	4.10	85.1
40	5,520	9,776	11,734	4.03	83.7
45	5,788	9,359	11,413	3.99	82.7
50	5,824	9,211	11,153	3.93	81.6
55	5,905	8,990	11,009	3.90	81.0
60	5,480	7,916	10,745	3.68	76.3
65	5,055	6,842	10,480	3.45	71.6
70	4,951	6,416	10,366	3.37	69.9
75	4,892	6,036	10,192	3.29	68.3
80	4,814	5,703	10,036	3.22	66.8
85	4,730	5,420	9,905	3.15	65.4
90	4,720	5,202	9,800	3.11	64.6
95	4,728	5,003	9,617	3.06	63.6
100	4,767	4,821	9,539	3.04	63.1
110	4,786	4,440	9,400	2.98	61.9
120	4,790	4,184	9,259	2.94	60.9
130	4,906	3,971	9,279	2.94	61.0
140	4,962	3,835	9,087	2.91	60.3
150	4,989	3,690	9,094	2.90	60.1
160	4,894	3,548	9,055	2.86	59.3
170	4,924	3,448	9,087	2.86	59.4
180	4,884	3,314	9,032	2.83	58.8
190	4,843	3,177	8,854	2.78	57.7
200	4,788	3,070	8,865	2.76	57.3
250	3,198	1,998	6,032	1.86	38.6
300	1,607	927	3,199	0.96	19.9
350	1,243	719	2,796	0.80	16.6
400	946	591	2,301	0.64	13.3
450	669	494	1,802	0.49	10.2
500	481	424	1,404	0.38	7.9
600	362	220	909	0.25	5.2
700	376	294	621	0.21	4.3
800	472	542	466	0.22	4.6
900	525	770	441	0.25	5.2
1,000	491	716	574	0.26	5.4

Table E-4. Chinook salmon juvenile weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	3,469	4,626	7,922	2.49	51.8
10	5,087	7,233	11,960	3.76	78.1
15	5,989	9,094	13,774	4.42	91.9
20	6,248	9,846	15,008	4.76	98.9
25	6,141	10,225	15,217	4.81	100.0
30	5,205	10,338	14,817	4.58	95.1
35	5,277	10,627	14,309	4.53	94.0
40	5,657	10,779	13,839	4.53	94.1
45	6,107	10,721	13,496	4.54	94.4
50	5,846	10,876	12,983	4.42	91.8
55	5,673	10,766	12,490	4.29	89.1
60	5,496	10,411	12,536	4.23	87.9
65	5,319	10,056	12,583	4.17	86.7
70	5,230	9,809	12,435	4.11	85.3
75	5,183	9,533	12,200	4.03	83.8
80	5,127	9,301	11,989	3.96	82.3
85	5,099	9,034	11,813	3.90	81.0
90	5,133	8,696	11,662	3.85	80.0
95	5,156	8,304	11,369	3.76	78.2
100	5,244	7,927	11,173	3.71	77.1
110	5,234	7,116	10,919	3.59	74.5
120	5,084	6,555	10,805	3.49	72.5
130	5,146	6,137	10,942	3.48	72.4
140	5,236	5,840	10,834	3.45	71.8
150	5,383	5,568	10,969	3.48	72.3
160	5,402	5,230	11,018	3.46	71.9
170	5,599	5,042	11,146	3.50	72.8
180	5,699	4,806	11,214	3.51	73.0
190	5,817	4,627	11,121	3.50	72.8
200	5,916	4,499	11,177	3.52	73.1
250	4,238	3,530	7,956	2.54	52.8
300	2,561	2,561	4,735	1.56	32.5
350	2,222	1,191	4,045	1.25	25.9
400	1,902	1,023	3,637	1.10	22.9
450	1,572	915	3,130	0.94	19.5
500	1,324	791	2,635	0.79	16.4
600	885	649	1,849	0.56	11.5
700	603	446	1,346	0.39	8.2
800	458	266	932	0.28	5.8
900	440	475	677	0.25	5.1
1,000	469	827	541	0.26	5.4

Table E-5. Coho salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	290	53	44	0.07	3.2
10	620	136	101	0.15	7.0
15	899	221	155	0.22	10.3
20	1,065	294	203	0.26	12.5
25	1,149	363	244	0.29	14.0
30	1,164	425	271	0.31	14.6
35	1,203	479	306	0.32	15.5
40	1,236	484	343	0.34	16.1
45	1,270	485	380	0.35	16.7
50	1,300	487	416	0.36	17.3
55	1,354	485	456	0.38	18.1
60	1,632	498	607	0.46	22.0
65	1,911	510	758	0.54	25.8
70	2,022	509	819	0.57	27.3
75	2,161	491	860	0.60	28.8
80	2,325	474	873	0.64	30.3
85	2,466	459	884	0.66	31.6
90	2,677	445	895	0.70	33.5
95	2,900	426	890	0.74	35.4
100	3,167	411	883	0.79	37.6
110	3,725	376	861	0.89	42.3
120	4,256	347	847	0.98	46.8
130	4,845	313	870	1.09	52.1
140	5,356	283	937	1.20	57.1
150	5,718	258	1,022	1.28	61.0
160	5,947	251	1,120	1.34	63.8
170	6,192	246	1,241	1.40	67.0
180	6,432	242	1,352	1.47	70.1
190	6,574	236	1,449	1.51	72.1
200	6,704	231	1,574	1.56	74.4
250	6,751	576	2,402	1.75	83.3
300	5,560	1,957	3,914	1.92	91.7
350	4,368	3,339	5,426	2.10	100.0
400	3,344	3,620	5,639	1.97	93.9
450	2,393	3,218	5,414	1.71	81.7
500	1,920	2,459	5,046	1.49	71.0
600	1,475	1,104	3,864	1.07	51.0
700	1,415	784	2,759	0.83	39.6
800	1,303	513	1,706	0.60	28.4
900	1,073	295	1,049	0.42	19.8
1,000	776	99	850	0.31	14.6

Table E-6. Coho salmon fry weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	9,223	15,068	14,581	5.72	100.0
10	8,072	13,354	14,422	5.32	93.0
15	7,035	12,550	12,977	4.80	83.8
20	6,759	11,533	12,115	4.50	78.5
25	6,692	10,413	11,739	4.31	75.3
30	6,203	9,390	11,411	4.07	71.0
35	6,168	8,758	11,090	3.94	68.9
40	6,759	8,123	10,664	3.92	68.5
45	7,670	7,680	10,397	4.00	69.9
50	7,821	7,412	10,131	3.96	69.2
55	7,916	7,127	9,859	3.90	68.2
60	6,946	5,895	9,617	3.56	62.2
65	5,976	4,663	9,376	3.22	56.3
70	5,892	4,479	9,398	3.19	55.8
75	5,840	4,352	9,392	3.17	55.4
80	5,761	4,281	9,341	3.14	54.9
85	5,687	4,176	9,248	3.10	54.2
90	5,649	4,074	9,204	3.08	53.8
95	5,583	3,935	9,047	3.02	52.8
100	5,548	3,812	8,922	2.98	52.1
110	5,341	3,585	8,633	2.87	50.2
120	5,153	3,404	8,268	2.76	48.1
130	5,040	3,151	8,147	2.69	47.0
140	4,849	2,937	7,947	2.60	45.4
150	4,678	2,742	7,881	2.54	44.3
160	4,427	2,629	7,672	2.44	42.6
170	4,259	2,531	7,591	2.39	41.7
180	4,011	2,574	7,510	2.33	40.7
190	3,829	2,628	7,385	2.28	39.8
200	3,672	2,681	7,358	2.25	39.3
250	2,931	2,590	6,959	2.03	35.5
300	1,973	1,693	4,527	1.33	23.3
350	1,015	797	2,096	0.64	11.1
400	744	661	1,741	0.51	8.9
450	589	549	1,416	0.41	7.2
500	517	418	1,103	0.33	5.8
600	551	459	799	0.29	5.0
700	799	723	720	0.34	6.0
800	781	1,144	769	0.39	6.8
900	726	943	947	0.39	6.9
1,000	751	639	1,013	0.38	6.6

Table E-7. Coho salmon juvenile weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)			Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3		
5	5,154	7,294	10,222	3.46	64.3
10	6,554	9,281	12,806	4.37	81.2
15	7,396	10,812	14,633	5.00	92.8
20	7,683	11,463	15,655	5.29	98.3
25	7,756	11,669	15,995	5.39	100.0
30	7,049	11,572	16,063	5.26	97.6
35	7,190	11,614	16,099	5.29	98.3
40	7,531	11,456	16,007	5.33	98.9
45	7,901	11,237	15,811	5.34	99.2
50	7,705	11,268	15,396	5.23	97.2
55	7,536	11,173	15,155	5.15	95.6
60	7,362	10,963	14,978	5.07	94.0
65	7,188	10,598	14,800	4.97	92.2
70	7,057	10,289	14,590	4.88	90.5
75	6,974	10,010	14,310	4.79	88.8
80	6,881	9,776	13,976	4.69	87.0
85	6,787	9,540	13,665	4.59	85.3
90	6,735	9,271	13,463	4.52	83.9
95	6,687	8,998	13,133	4.43	82.2
100	6,681	8,774	12,948	4.37	81.2
110	6,656	8,310	12,632	4.27	79.3
120	6,607	7,999	12,247	4.16	77.3
130	6,717	7,663	12,127	4.13	76.7
140	6,768	7,359	11,774	4.05	75.2
150	6,826	7,041	11,610	4.00	74.3
160	6,761	6,694	11,476	3.93	73.0
170	6,863	6,532	11,461	3.94	73.0
180	6,924	6,290	11,419	3.92	72.7
190	6,940	6,040	11,304	3.88	71.9
200	6,916	5,847	11,360	3.86	71.7
250	6,813	5,122	11,642	3.83	71.0
300	4,605	1,776	8,393	2.52	46.9
350	2,398	1,603	5,145	1.52	28.1
400	1,828	1,251	4,431	1.25	23.2
450	1,479	919	3,782	1.04	19.2
500	1,198	776	3,155	0.86	15.9
600	792	558	1,960	0.55	10.2
700	628	437	1,183	0.37	6.9
800	682	580	840	0.33	6.2
900	747	863	677	0.34	6.3
1,000	768	1,003	615	0.35	6.4

Table E-8. Steelhead trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	29	2	9	0.01	0.2
10	105	16	25	0.03	0.8
15	230	37	45	0.05	1.8
20	368	70	69	0.09	2.9
25	523	108	93	0.12	4.1
30	658	148	118	0.16	5.2
35	809	185	142	0.19	6.4
40	911	218	166	0.22	7.3
45	976	253	191	0.24	8.0
50	1,050	289	211	0.26	8.6
55	1,102	327	232	0.28	9.2
60	1,214	373	237	0.30	10.1
65	1,326	419	242	0.33	10.9
70	1,372	459	298	0.35	11.7
75	1,415	498	360	0.38	12.4
80	1,445	519	415	0.39	13.0
85	1,481	533	469	0.41	13.6
90	1,501	537	518	0.42	14.0
95	1,534	540	555	0.44	14.4
100	1,592	542	603	0.46	15.1
110	1,747	544	685	0.50	16.5
120	1,885	546	752	0.54	17.8
130	2,096	545	833	0.59	19.6
140	2,279	546	901	0.64	21.1
150	2,498	549	936	0.69	22.7
160	2,711	552	951	0.73	24.1
170	3,041	545	952	0.79	26.1
180	3,361	521	937	0.85	28.0
190	3,708	496	921	0.90	30.0
200	4,078	477	923	0.97	32.2
250	5,849	382	1,051	1.32	43.6
300	7,370	467	2,247	1.82	60.4
350	8,891	552	3,443	2.33	77.2
400	8,821	1,352	4,458	2.57	85.2
450	8,416	2,537	5,382	2.77	91.7
500	8,033	3,692	6,216	2.96	97.8
600	6,588	5,480	7,171	3.02	100.0
700	5,212	4,848	7,540	2.77	91.7
800	4,081	3,590	7,388	2.41	79.9
900	3,173	2,453	6,765	2.03	67.1
1,000	2,823	1,443	5,617	1.66	55.1

Table E-9. Rainbow trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	0	0	0	0.00	0.0
10	5	0	0	0.00	0.0
15	13	0	0	0.00	0.1
20	23	3	0	0.00	0.2
25	34	6	0	0.01	0.3
30	43	11	0	0.01	0.4
35	49	17	0	0.01	0.4
40	50	22	0	0.01	0.5
45	51	29	0	0.01	0.5
50	53	36	0	0.01	0.5
55	55	43	0	0.01	0.6
60	66	51	50	0.03	1.1
65	77	55	99	0.04	1.5
70	82	59	155	0.05	2.0
75	88	59	206	0.06	2.4
80	96	59	241	0.07	2.7
85	106	59	276	0.07	3.1
90	120	59	311	0.08	3.4
95	133	59	334	0.09	3.7
100	150	59	369	0.10	4.1
110	183	59	427	0.12	4.7
120	223	59	473	0.13	5.4
130	279	59	532	0.15	6.2
140	351	59	578	0.17	7.1
150	459	59	582	0.20	8.0
160	575	59	585	0.22	8.9
170	730	59	595	0.25	10.2
180	902	59	609	0.28	11.6
190	1,052	59	625	0.31	12.8
200	1,198	59	565	0.33	13.5
250	1,851	47	312	0.41	16.6
300	2,614	142	2,097	0.88	35.9
350	3,377	992	3,882	1.42	57.9
400	3,524	2,053	4,940	1.73	70.8
450	3,639	3,189	5,963	2.04	83.5
500	3,565	4,271	6,615	2.24	91.8
600	2,667	5,349	7,295	2.30	93.9
700	2,374	5,386	8,014	2.37	97.1
800	2,349	5,386	8,443	2.45	100.0
900	2,133	3,650	8,122	2.19	89.4
1,000	1,745	1,624	7,329	1.78	73.0

Table E-10. Rainbow trout fry weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	14,815	22,034	18,515	8.12	83.7
10	16,815	24,289	22,131	9.35	96.3
15	16,952	24,739	23,745	9.70	100.0
20	16,424	23,973	24,411	9.65	99.5
25	16,012	22,726	24,438	9.46	97.5
30	14,581	21,242	23,933	8.97	92.4
35	14,510	20,173	23,349	8.75	90.2
40	15,468	19,119	22,684	8.71	89.8
45	16,749	18,039	22,092	8.75	90.2
50	16,644	17,409	21,355	8.54	88.0
55	16,663	16,711	20,734	8.37	86.2
60	16,335	15,525	20,999	8.24	85.0
65	16,008	14,340	21,264	8.12	83.7
70	15,930	13,708	21,023	8.00	82.5
75	15,902	13,162	20,695	7.89	81.3
80	15,749	12,721	20,388	7.77	80.0
85	15,562	12,227	20,104	7.63	78.7
90	15,426	11,770	19,787	7.51	77.4
95	15,301	11,332	19,333	7.36	75.9
100	15,260	10,930	18,915	7.24	74.7
110	15,029	10,204	18,183	7.00	72.2
120	14,653	9,715	17,575	6.78	69.9
130	14,310	9,295	17,241	6.62	68.2
140	13,844	8,952	16,776	6.41	66.1
150	13,410	8,589	16,578	6.26	64.6
160	12,940	8,236	16,289	6.09	62.8
170	12,658	7,927	16,149	5.99	61.7
180	12,271	7,747	16,034	5.88	60.6
190	11,841	7,576	15,858	5.75	59.2
200	11,425	7,460	15,773	5.64	58.2
250	9,775	7,093	15,271	5.21	53.7
300	6,345	4,868	10,709	3.55	36.6
350	2,916	2,643	6,146	1.89	19.5
400	2,403	2,009	5,077	1.54	15.9
450	2,057	1,628	4,068	1.26	13.0
500	1,795	1,379	3,147	1.03	10.6
600	1,394	1,113	1,822	0.69	7.1
700	1,272	1,114	1,324	0.58	6.0
800	1,314	1,485	1,202	0.60	6.2
900	1,345	1,779	1,263	0.64	6.6
1,000	1,271	1,505	1,411	0.63	6.5

Table E-11. Rainbow trout juvenile weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	4,198	5,346	9,030	2.89	37.0
10	6,530	8,755	12,728	4.30	55.1
15	8,424	11,898	14,792	5.32	68.1
20	10,232	14,374	16,697	6.23	79.7
25	11,800	15,933	18,144	6.92	88.6
30	11,768	16,396	19,232	7.15	91.6
35	12,366	16,729	20,148	7.46	95.5
40	12,849	16,909	20,629	7.65	98.0
45	13,344	16,870	21,025	7.81	100.0
50	12,747	17,158	21,220	7.76	99.4
55	12,114	17,329	21,306	7.67	98.2
60	11,706	17,414	21,431	7.63	97.6
65	11,297	17,499	21,556	7.58	97.1
70	10,869	17,248	21,701	7.50	96.1
75	10,719	17,080	21,700	7.46	95.5
80	10,586	16,951	21,639	7.41	94.9
85	10,513	16,724	21,587	7.37	94.3
90	10,531	16,487	21,507	7.34	93.9
95	10,533	16,304	21,129	7.25	92.8
100	10,692	16,114	20,761	7.20	92.1
110	10,980	15,654	20,045	7.08	90.7
120	11,004	15,107	19,446	6.93	88.7
130	11,160	14,586	19,263	6.88	88.0
140	11,189	14,183	18,543	6.72	86.0
150	11,221	13,758	18,100	6.60	84.5
160	11,065	13,267	17,721	6.46	82.7
170	11,229	12,866	17,582	6.43	82.3
180	11,271	12,332	17,440	6.36	81.5
190	11,218	11,783	17,182	6.26	80.1
200	11,139	11,389	17,118	6.20	79.3
250	11,299	9,804	16,768	6.02	77.0
300	8,498	6,733	13,671	4.65	59.6
350	5,698	3,663	10,574	3.29	42.1
400	4,434	3,434	8,641	2.69	34.4
450	3,626	3,067	7,284	2.26	29.0
500	3,142	2,573	6,317	1.95	25.0
600	2,592	2,160	4,836	1.55	19.8
700	2,172	1,812	3,418	1.18	15.2
800	1,748	1,370	2,360	0.88	11.2
900	1,472	1,295	1,835	0.72	9.3
1,000	1,236	1,510	1,442	0.63	8.0

Table E-12. Rainbow trout adult weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	1,242	1,413	3,415	0.97	16.8
10	1,986	2,488	5,159	1.52	26.2
15	2,791	3,816	6,640	2.06	35.5
20	3,584	4,898	8,028	2.56	44.0
25	4,421	5,837	9,325	3.03	52.2
30	4,914	6,628	10,472	3.40	58.6
35	5,737	7,422	11,501	3.81	65.7
40	6,534	8,038	12,395	4.18	72.0
45	7,253	8,493	13,246	4.51	77.7
50	7,571	9,057	13,944	4.74	81.7
55	7,803	9,464	14,552	4.93	85.0
60	8,350	10,051	15,062	5.18	89.3
65	8,897	10,639	15,572	5.43	93.5
70	8,923	10,893	15,980	5.53	95.3
75	8,956	11,197	16,347	5.63	97.0
80	8,876	11,505	16,643	5.70	98.1
85	8,780	11,717	16,916	5.75	99.0
90	8,726	11,889	17,089	5.78	99.6
95	8,674	11,989	17,098	5.79	99.7
100	8,677	12,053	17,172	5.80	100.0
110	8,571	12,114	17,245	5.80	100.0
120	8,295	12,385	17,130	5.76	99.2
130	8,221	12,519	17,241	5.77	99.5
140	8,148	12,672	17,036	5.74	98.9
150	8,185	12,810	16,988	5.75	99.1
160	8,107	12,827	16,756	5.70	98.1
170	8,263	12,948	16,635	5.71	98.4
180	8,299	12,966	16,413	5.68	97.9
190	8,311	12,932	16,009	5.61	96.7
200	8,356	12,982	15,836	5.59	96.3
250	8,540	12,862	15,022	5.47	94.2
300	8,225	9,813	14,337	5.01	86.3
350	7,911	6,764	13,652	4.54	78.3
400	7,345	5,911	12,636	4.18	72.0
450	6,657	5,303	11,701	3.83	65.9
500	6,052	4,817	10,766	3.50	60.3
600	4,991	4,047	8,862	2.89	49.8
700	3,905	3,388	7,074	2.31	39.7
800	3,147	2,684	5,509	1.82	31.4
900	2,623	2,285	4,358	1.48	25.5
1,000	2,246	1,999	3,441	1.22	21.0

Table E-13. Bull trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	62	0	0	0.01	0.5
10	126	41	0	0.03	1.2
15	151	106	0	0.04	1.6
20	183	144	0	0.05	2.1
25	218	153	0	0.06	2.4
30	254	154	0	0.06	2.7
35	283	156	15	0.07	3.0
40	304	158	42	0.08	3.4
45	324	160	75	0.09	3.8
50	397	163	109	0.11	4.7
55	496	165	148	0.13	5.8
60	680	170	367	0.21	9.0
65	864	176	586	0.28	12.2
70	1,017	177	594	0.31	13.5
75	1,186	178	612	0.35	15.0
80	1,384	178	629	0.39	16.7
85	1,563	178	650	0.43	18.3
90	1,806	178	653	0.47	20.3
95	2,082	167	622	0.52	22.2
100	2,302	159	609	0.55	23.9
110	2,729	142	615	0.63	27.3
120	3,077	131	653	0.71	30.4
130	3,406	120	753	0.78	33.7
140	3,769	109	896	0.88	37.7
150	4,117	115	1,040	0.97	41.7
160	4,379	153	1,235	1.05	45.4
170	4,639	181	1,457	1.15	49.3
180	4,860	212	1,676	1.23	52.9
190	4,993	233	1,864	1.29	55.5
200	5,053	255	2,163	1.36	58.4
250	4,840	1,191	3,922	1.72	73.9
300	4,094	3,046	5,440	2.02	87.0
350	3,349	4,901	6,958	2.32	100.0
400	2,564	5,495	7,114	2.26	97.2
450	1,819	4,260	7,182	2.02	86.8
500	1,445	2,833	7,044	1.79	77.1
600	1,210	959	6,272	1.43	61.8
700	1,242	501	4,137	1.02	43.8
800	1,212	104	2,254	0.64	27.5
900	1,080	13	1,145	0.41	17.6
1,000	747	3	1,006	0.32	13.8

Table E-14. Bull trout fry weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)			Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3		
5	8,124	15,861	14,849	5.64	100.0
10	6,743	13,793	13,612	4.97	88.1
15	5,375	12,333	11,918	4.28	75.8
20	4,817	10,562	10,707	3.79	67.2
25	4,644	8,982	10,016	3.49	61.9
30	4,061	7,841	9,351	3.15	55.9
35	3,947	7,268	8,886	3.00	53.2
40	4,167	6,670	8,344	2.89	51.2
45	4,704	6,281	8,239	2.93	52.0
50	5,020	6,041	8,076	2.94	52.1
55	5,474	5,780	7,937	2.98	52.8
60	4,414	4,153	7,943	2.63	46.6
65	3,355	2,525	7,948	2.28	40.4
70	3,440	2,344	8,011	2.29	40.6
75	3,534	2,205	8,070	2.31	40.9
80	3,623	2,145	8,038	2.31	41.0
85	3,641	2,093	7,897	2.28	40.5
90	3,719	2,039	7,804	2.28	40.4
95	3,740	1,944	7,593	2.24	39.6
100	3,800	1,839	7,429	2.21	39.1
110	3,747	1,686	7,108	2.13	37.7
120	3,642	1,540	6,762	2.03	36.0
130	3,527	1,354	6,686	1.98	35.1
140	3,287	1,203	6,527	1.89	33.5
150	3,132	1,084	6,454	1.84	32.6
160	2,932	1,016	6,349	1.78	31.5
170	2,810	911	6,312	1.74	30.8
180	2,566	851	6,209	1.67	29.6
190	2,379	753	5,999	1.59	28.1
200	2,222	706	5,960	1.54	27.4
250	1,357	957	5,939	1.40	24.9
300	754	598	3,292	0.78	13.9
350	151	240	646	0.17	2.9
400	129	104	463	0.12	2.1
450	177	68	395	0.11	1.9
500	152	65	230	0.08	1.3
600	166	175	126	0.07	1.2
700	326	386	222	0.14	2.4
800	427	1,121	530	0.28	4.9
900	488	991	885	0.34	6.1
1,000	578	418	1,081	0.34	6.0

Table E-15. Bull trout juvenile weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	6,846	9,448	13,001	4.48	49.6
10	9,212	12,861	15,720	5.72	63.3
15	11,437	16,214	17,656	6.79	75.2
20	13,220	18,445	19,424	7.65	84.7
25	14,390	19,602	20,718	8.21	90.9
30	14,106	20,033	21,653	8.36	92.6
35	14,737	20,460	22,398	8.65	95.8
40	15,251	20,403	23,049	8.86	98.1
45	15,678	20,193	23,681	9.03	100.0
50	15,146	20,168	23,894	8.97	99.3
55	14,618	19,850	24,056	8.87	98.2
60	14,793	19,771	24,229	8.92	98.8
65	14,967	19,691	24,402	8.98	99.4
70	14,573	19,269	24,467	8.88	98.3
75	14,276	19,024	24,443	8.80	97.4
80	13,933	18,812	24,247	8.68	96.1
85	13,644	18,517	24,036	8.56	94.8
90	13,561	18,123	23,907	8.48	93.9
95	13,469	17,669	23,589	8.37	92.6
100	13,486	17,232	23,390	8.29	91.8
110	13,352	16,461	22,896	8.11	89.8
120	13,050	16,016	22,141	7.88	87.2
130	13,105	15,485	21,773	7.77	86.1
140	13,136	14,960	21,203	7.63	84.5
150	13,220	14,489	20,963	7.56	83.7
160	13,081	14,001	20,467	7.40	81.9
170	13,237	13,699	20,033	7.32	81.1
180	13,254	13,358	19,578	7.21	79.9
190	13,292	12,944	19,104	7.10	78.6
200	13,284	12,634	18,779	7.01	77.6
250	12,801	11,169	17,461	6.55	72.5
300	9,973	7,750	14,373	5.15	57.0
350	7,145	4,331	11,286	3.75	41.6
400	5,674	3,863	9,701	3.15	34.9
450	4,293	3,506	8,308	2.61	28.9
500	3,543	3,146	7,026	2.21	24.5
600	2,533	2,438	4,930	1.58	17.5
700	2,087	1,887	3,505	1.19	13.2
800	1,820	1,644	2,424	0.93	10.2
900	1,711	1,747	1,740	0.79	8.8
1,000	1,677	1,940	1,428	0.75	8.3

Table E-16. Bull trout adult weighted usable area and total habitat area versus discharge relationships for Reach 2; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	1,752	1,985	5,018	1.41	27.2
10	2,398	3,077	6,771	1.94	37.6
15	3,072	4,424	8,034	2.42	46.8
20	3,781	5,502	9,180	2.86	55.2
25	4,564	6,390	10,307	3.29	63.6
30	4,965	7,060	11,320	3.60	69.7
35	5,656	7,722	12,253	3.96	76.6
40	6,332	8,143	13,093	4.28	82.7
45	6,946	8,424	13,821	4.55	88.0
50	7,113	8,878	14,333	4.71	91.2
55	7,172	9,163	14,809	4.83	93.5
60	7,446	9,519	14,944	4.94	95.6
65	7,721	9,874	15,079	5.05	97.7
70	7,590	10,049	15,381	5.10	98.6
75	7,498	10,230	15,567	5.13	99.2
80	7,326	10,407	15,707	5.14	99.4
85	7,148	10,523	15,821	5.14	99.4
90	6,994	10,634	15,916	5.13	99.3
95	6,866	10,717	15,833	5.10	98.7
100	6,826	10,817	15,866	5.11	98.9
110	6,776	10,989	15,865	5.12	99.0
120	6,779	11,307	15,696	5.12	99.0
130	6,958	11,481	15,709	5.17	100.0
140	7,064	11,639	15,339	5.14	99.4
150	7,183	11,745	15,140	5.13	99.3
160	7,225	11,712	14,783	5.08	98.2
170	7,449	11,824	14,611	5.10	98.6
180	7,561	11,774	14,413	5.08	98.2
190	7,624	11,698	14,150	5.04	97.4
200	7,702	11,706	14,061	5.04	97.4
250	8,089	11,100	13,523	4.96	95.9
300	7,325	8,356	12,327	4.34	84.1
350	6,561	5,611	11,130	3.73	72.2
400	5,865	5,001	10,348	3.41	65.9
450	5,229	4,538	9,421	3.08	59.6
500	4,665	4,249	8,357	2.76	53.4
600	3,694	3,730	6,401	2.18	42.2
700	3,233	3,175	5,078	1.81	34.9
800	2,989	2,701	4,156	1.55	30.0
900	2,735	2,425	3,466	1.36	26.2
1,000	2,420	2,273	2,825	1.17	22.6

APPENDIX F

Weighted Usable Area (WUA) and Total Habitat Area (HA) Versus Flow Relationships for Reach 3

Table F-1. Spring chinook salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	86	0	12	0.02	0.1
10	660	350	878	0.25	1.9
15	1,670	780	3,512	0.75	5.8
20	3,037	1,630	7,013	1.45	11.2
25	4,557	2,695	10,492	2.19	17.0
30	6,562	4,523	13,423	3.05	23.6
35	8,613	7,030	16,108	3.95	30.5
40	10,474	9,750	18,282	4.78	37.0
45	12,167	12,613	19,965	5.54	42.9
50	13,726	15,378	21,376	6.24	48.3
55	15,235	17,724	22,735	6.89	53.3
60	16,509	19,956	24,748	7.54	58.3
65	17,782	22,188	26,760	8.19	63.4
70	18,845	24,427	27,923	8.72	67.5
75	19,789	26,605	28,708	9.18	71.1
80	20,592	28,960	29,406	9.62	74.5
85	21,447	30,740	29,972	10.01	77.5
90	22,212	32,391	30,629	10.38	80.3
95	22,852	33,769	31,236	10.69	82.7
100	23,414	34,903	31,758	10.95	84.8
110	24,350	37,461	32,482	11.44	88.5
120	25,074	39,059	33,348	11.81	91.4
130	25,783	40,791	32,604	12.04	93.2
140	26,271	41,847	33,215	12.29	95.1
150	26,593	42,625	33,824	12.48	96.6
160	26,782	43,016	33,747	12.55	97.1
170	26,858	43,299	33,474	12.56	97.2
180	26,941	43,410	33,326	12.58	97.3
190	26,827	43,058	35,038	12.69	98.2
200	26,713	42,808	36,750	12.81	99.2
250	26,491	39,691	40,479	12.86	99.5
300	26,268	36,574	44,412	12.92	100.0
350	24,152	31,857	48,346	12.46	96.4
400	22,195	27,941	48,778	11.76	91.0
450	19,373	25,084	50,062	11.06	85.6
500	16,837	22,794	49,669	10.31	79.8
600	11,771	19,646	47,050	8.75	67.7
700	8,054	17,897	42,393	7.39	57.2
800	5,418	17,072	37,520	6.30	48.8
900	3,792	16,405	32,823	5.45	42.2
1,000	2,628	15,371	28,621	4.71	36.5

Table F-2. Fall chinook salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	30	0	2	0.01	0.0
10	403	0	257	0.11	0.8
15	1,086	51	1,412	0.36	2.9
20	2,064	188	3,332	0.76	6.0
25	3,319	531	5,823	1.29	10.2
30	4,988	1,288	8,375	1.94	15.4
35	6,721	2,281	10,686	2.61	20.7
40	8,565	3,445	13,144	3.33	26.4
45	10,433	4,927	15,348	4.05	32.1
50	12,472	6,571	17,276	4.80	38.0
55	14,370	8,289	18,976	5.50	43.6
60	16,031	9,975	20,844	6.17	48.9
65	17,693	11,660	22,712	6.84	54.2
70	19,302	13,665	23,995	7.47	59.2
75	20,785	15,695	25,088	8.06	63.9
80	21,980	18,009	26,074	8.60	68.2
85	23,219	20,060	26,869	9.11	72.2
90	24,310	21,941	27,222	9.53	75.6
95	25,238	23,825	27,622	9.93	78.7
100	26,063	25,189	27,949	10.25	81.2
110	27,724	28,189	28,470	10.90	86.4
120	29,075	30,224	29,274	11.43	90.6
130	30,356	32,595	27,996	11.78	93.4
140	31,225	34,258	28,342	12.13	96.2
150	31,704	35,702	29,259	12.45	98.7
160	32,027	36,832	29,048	12.60	99.9
170	32,035	37,660	28,354	12.60	99.9
180	32,053	38,221	27,928	12.61	100.0
190	31,793	38,082	27,608	12.52	99.2
200	31,417	38,034	27,477	12.42	98.5
250	29,592	35,229	33,216	12.37	98.1
300	27,767	32,424	35,753	12.00	95.2
350	24,347	28,441	38,289	11.21	88.8
400	21,995	25,385	38,175	10.45	82.8
450	19,477	23,553	38,304	9.79	77.6
500	17,344	22,488	37,743	9.21	73.0
600	13,685	21,349	36,735	8.27	65.6
700	10,620	19,481	34,044	7.22	57.3
800	8,093	17,756	30,246	6.19	49.0
900	5,936	16,307	27,198	5.32	42.2
1,000	4,533	15,010	24,995	4.71	37.3

Table F-3. Chinook salmon fry weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	18,401	17,697	9,981	6.27	72.0
10	21,685	19,574	13,761	7.47	85.7
15	23,603	20,707	15,743	8.15	93.6
20	24,549	21,344	16,622	8.49	97.4
25	25,172	21,825	17,195	8.71	100.0
30	24,933	21,876	17,182	8.67	99.5
35	24,271	21,682	17,219	8.52	97.8
40	23,829	21,133	17,529	8.41	96.6
45	23,345	20,877	17,625	8.30	95.3
50	22,442	20,427	17,673	8.08	92.8
55	21,505	19,759	17,946	7.86	90.2
60	20,672	19,353	17,733	7.64	87.7
65	19,840	18,947	17,519	7.41	85.1
70	18,884	18,311	17,419	7.15	82.1
75	18,070	17,739	17,362	6.93	79.6
80	17,323	17,234	17,445	6.74	77.4
85	16,804	16,630	17,647	6.60	75.8
90	16,374	16,067	17,500	6.45	74.1
95	15,769	15,518	17,496	6.28	72.1
100	15,350	14,967	17,518	6.15	70.6
110	14,437	14,074	17,248	5.86	67.3
120	13,740	13,384	17,289	5.66	65.0
130	13,159	12,744	20,354	5.79	66.5
140	12,512	12,093	20,113	5.58	64.0
150	11,990	11,536	17,870	5.20	59.7
160	11,340	10,970	18,234	5.06	58.0
170	10,813	10,453	17,790	4.86	55.8
180	10,438	10,005	18,189	4.78	54.9
190	9,988	9,546	18,951	4.73	54.3
200	9,633	9,140	20,139	4.74	54.4
250	6,789	7,737	15,710	3.60	41.4
300	3,946	6,334	11,281	2.47	28.3
350	3,131	5,633	11,133	2.23	25.6
400	2,593	5,089	10,758	2.03	23.3
450	2,207	4,550	10,449	1.88	21.6
500	1,883	4,319	9,486	1.70	19.5
600	1,360	3,963	7,732	1.39	15.9
700	860	3,526	7,244	1.20	13.8
800	619	3,115	6,503	1.04	12.0
900	535	2,718	5,577	0.90	10.3
1,000	565	2,715	4,740	0.82	9.4

Table F-4. Chinook salmon juvenile weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)			Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3		
5	7,706	7,415	4,496	2.66	28.2
10	11,796	9,988	8,217	4.08	43.3
15	15,569	12,356	11,198	5.34	56.7
20	18,495	14,715	13,803	6.40	67.9
25	20,739	16,670	15,740	7.21	76.6
30	22,372	18,348	16,667	7.78	82.7
35	23,361	19,844	17,009	8.15	86.6
40	24,372	20,796	17,344	8.47	90.0
45	25,366	21,921	17,416	8.78	93.2
50	25,811	22,726	17,381	8.94	94.9
55	25,939	23,257	17,526	9.03	95.8
60	26,338	24,021	18,003	9.22	97.9
65	26,738	24,786	18,479	9.42	100.0
70	26,202	24,884	18,286	9.30	98.7
75	25,535	24,804	18,173	9.15	97.1
80	24,726	24,721	18,388	9.00	95.5
85	24,093	24,542	18,820	8.89	94.5
90	23,537	24,345	18,791	8.76	93.1
95	22,712	24,137	18,946	8.59	91.3
100	22,154	23,824	19,102	8.47	89.9
110	20,859	23,183	19,142	8.15	86.6
120	19,984	22,549	19,390	7.94	84.4
130	19,169	21,972	22,513	8.04	85.3
140	18,317	21,390	22,321	7.79	82.8
150	17,665	21,040	19,990	7.40	78.6
160	16,752	20,617	20,304	7.21	76.6
170	15,984	20,135	19,683	6.95	73.8
180	15,347	19,684	20,143	6.83	72.5
190	14,752	19,163	21,106	6.76	71.8
200	14,380	18,648	22,347	6.76	71.8
250	11,172	16,258	17,980	5.47	58.1
300	7,965	13,869	13,613	4.18	44.4
350	6,084	11,230	14,163	3.62	38.4
400	4,995	9,497	14,803	3.31	35.1
450	4,171	8,630	15,216	3.11	33.0
500	3,664	7,980	14,810	2.91	30.9
600	2,759	6,882	13,235	2.47	26.2
700	2,132	6,323	10,862	2.06	21.9
800	1,565	5,691	8,924	1.70	18.1
900	1,038	5,012	8,257	1.47	15.6
1,000	779	4,292	7,466	1.27	13.5

Table F-5. Coho salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	3,045	3,218	4,031	1.30	10.8
10	6,048	6,761	9,221	2.73	22.8
15	8,952	10,427	14,051	4.12	34.3
20	11,859	14,162	17,884	5.41	45.2
25	14,315	17,697	21,048	6.53	54.5
30	16,440	21,109	23,346	7.49	62.5
35	18,257	24,109	25,017	8.29	69.2
40	19,864	26,642	26,426	8.98	74.9
45	21,298	28,965	27,065	9.54	79.6
50	22,502	31,004	27,441	10.00	83.4
55	23,463	32,470	27,650	10.34	86.3
60	24,452	34,627	29,203	10.89	90.9
65	25,440	36,784	30,755	11.43	95.4
70	26,061	37,711	30,888	11.65	97.2
75	26,524	38,357	30,827	11.80	98.4
80	26,777	39,271	30,709	11.92	99.5
85	27,054	39,535	30,562	11.98	100.0
90	27,222	39,581	30,122	11.98	100.0
95	27,069	39,484	29,834	11.91	99.4
100	26,998	39,073	29,628	11.84	98.8
110	26,730	38,666	28,750	11.66	97.3
120	26,480	37,539	28,046	11.44	95.5
130	26,258	36,518	28,337	11.33	94.6
140	25,607	34,928	27,340	10.96	91.5
150	24,850	33,423	25,533	10.50	87.6
160	23,770	31,996	24,901	10.09	84.2
170	22,900	30,664	23,801	9.69	80.9
180	22,198	29,427	23,405	9.40	78.4
190	21,425	27,988	23,302	9.10	76.0
200	20,863	26,803	23,386	8.89	74.2
250	18,363	23,701	26,952	8.46	70.6
300	15,863	20,600	30,518	8.03	67.0
350	13,234	18,558	29,042	7.18	59.9
400	10,961	16,529	28,714	6.51	54.3
450	8,772	14,825	28,675	5.91	49.3
500	6,807	13,517	26,617	5.19	43.3
600	3,984	11,440	22,557	4.04	33.7
700	2,263	10,070	18,904	3.21	26.8
800	1,364	9,318	15,525	2.63	22.0
900	946	8,823	12,445	2.20	18.4
1,000	652	8,238	9,956	1.84	15.4

Table F-6. Coho salmon fry weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)			Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3		
5	24,999	24,275	17,567	8.93	94.8
10	26,543	24,843	18,848	9.42	100.0
15	25,329	23,716	18,899	9.08	96.4
20	23,372	22,232	18,885	8.55	90.8
25	21,793	20,681	19,135	8.12	86.2
30	20,121	19,226	19,288	7.67	81.4
35	18,353	17,952	19,241	7.19	76.4
40	16,998	16,723	19,361	6.82	72.4
45	16,023	15,769	19,292	6.53	69.4
50	15,101	14,760	19,152	6.24	66.3
55	14,395	13,815	19,154	6.02	63.9
60	13,449	12,918	18,069	5.64	59.9
65	12,503	12,020	16,984	5.26	55.9
70	12,034	11,553	16,785	5.11	54.2
75	11,626	11,143	16,556	4.96	52.7
80	11,219	10,847	16,480	4.85	51.5
85	10,894	10,471	16,540	4.76	50.5
90	10,628	10,131	16,375	4.66	49.4
95	10,281	9,830	16,446	4.57	48.5
100	10,051	9,490	16,561	4.50	47.8
110	9,577	8,919	16,404	4.34	46.1
120	9,204	8,360	16,519	4.22	44.9
130	8,907	7,920	18,917	4.36	46.3
140	8,539	7,479	18,755	4.23	44.9
150	8,180	7,116	16,430	3.90	41.4
160	7,731	6,783	16,588	3.79	40.3
170	7,363	6,499	16,138	3.65	38.8
180	7,086	6,268	16,381	3.60	38.2
190	6,754	6,034	17,410	3.61	38.3
200	6,519	5,823	16,173	3.42	36.3
250	4,735	4,848	14,936	2.85	30.3
300	2,952	3,872	10,380	1.96	20.8
350	2,482	3,575	9,281	1.73	18.4
400	1,970	3,362	8,569	1.54	16.3
450	1,712	3,208	8,417	1.46	15.5
500	1,355	2,959	8,212	1.34	14.3
600	977	2,482	7,243	1.13	12.0
700	837	2,333	6,543	1.02	10.8
800	715	2,473	5,736	0.93	9.9
900	885	2,592	4,758	0.88	9.3
1,000	1,088	2,733	4,173	0.87	9.3

Table F-7. Coho salmon juvenile weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	17,357	21,167	7,896	6.16	58.8
10	20,060	22,552	11,430	7.18	68.5
15	22,186	23,664	14,219	7.98	76.1
20	23,703	24,654	16,269	8.58	81.8
25	25,142	25,553	17,847	9.10	86.8
30	26,117	26,324	18,751	9.45	90.2
35	26,797	26,923	19,445	9.71	92.7
40	27,580	27,197	20,160	9.97	95.1
45	28,231	27,730	20,470	10.18	97.1
50	28,471	28,082	20,594	10.27	97.9
55	28,464	28,133	20,804	10.29	98.2
60	28,598	28,338	21,321	10.39	99.1
65	28,732	28,542	21,837	10.48	100.0
70	28,441	28,343	21,663	10.39	99.1
75	28,129	28,115	21,521	10.29	98.2
80	27,670	28,016	21,626	10.20	97.3
85	27,345	27,751	21,948	10.14	96.8
90	26,958	27,466	21,786	10.02	95.6
95	26,217	27,181	21,796	9.85	94.0
100	25,680	26,740	21,818	9.71	92.6
110	24,431	26,077	21,492	9.36	89.3
120	23,438	25,268	21,506	9.09	86.7
130	22,603	24,457	24,580	9.15	87.3
140	21,523	23,580	24,167	8.82	84.1
150	20,620	22,865	21,750	8.33	79.5
160	19,491	22,149	22,041	8.07	77.0
170	18,662	21,483	21,373	7.78	74.2
180	17,957	20,866	21,740	7.62	72.7
190	17,108	20,252	22,602	7.48	71.3
200	16,460	19,688	23,892	7.42	70.8
250	12,689	17,401	21,158	6.19	59.0
300	8,919	15,114	18,424	4.96	47.3
350	6,936	13,085	17,804	4.31	41.2
400	5,637	11,399	18,025	3.92	37.4
450	4,558	10,068	18,111	3.60	34.3
500	3,732	9,245	17,253	3.27	31.2
600	2,748	8,278	15,258	2.79	26.6
700	2,051	7,325	13,675	2.41	23.0
800	1,457	6,493	11,865	2.04	19.4
900	1,184	5,914	10,323	1.78	17.0
1,000	929	5,655	8,990	1.57	15.0

Table F-8. Steelhead trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)			Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3		
5	197	16	206	0.06	0.4
10	880	139	1,235	0.31	2.1
15	1,873	693	2,740	0.71	4.7
20	2,999	1,458	4,507	1.18	7.8
25	4,171	2,359	6,625	1.70	11.2
30	5,366	3,420	8,784	2.25	14.8
35	6,543	4,651	10,857	2.80	18.5
40	7,822	5,898	12,969	3.38	22.3
45	9,135	7,372	15,024	3.98	26.2
50	10,467	8,967	16,886	4.57	30.1
55	11,738	10,606	18,680	5.15	33.9
60	12,772	12,347	20,277	5.67	37.4
65	13,806	14,089	21,874	6.19	40.8
70	14,985	15,875	23,366	6.73	44.4
75	16,141	17,676	24,633	7.25	47.8
80	17,199	19,638	25,721	7.75	51.1
85	18,241	21,397	26,760	8.21	54.2
90	19,208	23,221	27,728	8.67	57.1
95	20,141	25,035	28,558	9.10	60.0
100	20,973	26,638	29,313	9.48	62.5
110	22,644	30,049	30,760	10.27	67.7
120	23,943	32,841	32,067	10.91	71.9
130	25,066	35,781	31,908	11.38	75.0
140	26,082	38,134	33,035	11.90	78.5
150	26,973	40,180	34,818	12.44	82.0
160	27,720	41,872	35,397	12.80	84.4
170	28,319	43,331	35,990	13.11	86.4
180	28,869	44,600	36,334	13.37	88.1
190	29,302	45,339	36,337	13.52	89.1
200	29,669	45,930	36,421	13.65	90.0
250	31,038	45,567	43,332	14.58	96.1
300	32,406	45,205	46,848	15.17	100.0
350	31,584	41,489	50,363	15.02	99.0
400	30,838	37,708	51,151	14.61	96.3
450	28,449	34,471	52,638	13.98	92.2
500	25,834	31,821	52,946	13.25	87.4
600	20,671	28,282	53,115	11.91	78.5
700	16,530	26,051	51,483	10.71	70.6
800	13,118	24,377	48,029	9.54	62.9
900	10,390	22,936	43,474	8.41	55.5
1,000	8,176	21,378	39,071	7.39	48.7

Table F-9. Rainbow trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	29	0	1	0.01	0.0
10	219	237	481	0.11	0.7
15	607	610	2,045	0.38	2.4
20	1,182	1,261	4,169	0.76	4.8
25	1,786	2,054	6,561	1.19	7.5
30	2,656	3,307	9,067	1.72	10.9
35	3,583	5,018	11,617	2.31	14.6
40	4,505	6,980	13,964	2.90	18.3
45	5,399	9,084	15,983	3.47	21.9
50	6,232	11,341	17,754	4.01	25.3
55	7,014	13,491	19,366	4.52	28.5
60	7,410	15,477	20,979	4.94	31.1
65	7,805	17,462	22,591	5.35	33.7
70	8,482	19,657	24,122	5.83	36.8
75	9,070	21,892	25,300	6.27	39.5
80	9,611	24,261	26,273	6.68	42.1
85	10,143	26,366	27,118	7.06	44.5
90	10,607	28,355	28,142	7.43	46.9
95	11,044	30,233	29,064	7.78	49.0
100	11,442	31,911	29,952	8.09	51.0
110	12,257	35,588	31,683	8.76	55.2
120	12,982	38,239	33,423	9.31	58.7
130	13,718	40,759	33,049	9.65	60.8
140	14,385	42,643	34,672	10.11	63.7
150	14,977	44,290	37,523	10.65	67.2
160	15,510	45,664	38,617	10.99	69.3
170	15,991	46,884	40,059	11.34	71.5
180	16,443	48,070	40,882	11.62	73.3
190	16,873	49,081	41,025	11.81	74.5
200	17,316	50,141	41,025	11.99	75.6
250	20,228	52,198	50,537	13.70	86.4
300	23,141	54,256	56,744	15.08	95.1
350	24,763	51,429	62,951	15.76	99.4
400	25,850	47,180	65,540	15.86	100.0
450	25,723	42,664	67,946	15.67	98.8
500	24,316	38,034	68,902	15.06	95.0
600	19,561	30,520	68,421	13.39	84.4
700	14,628	25,659	66,823	11.80	74.4
800	11,086	24,143	63,960	10.67	67.3
900	8,893	23,727	58,906	9.70	61.2
1,000	7,759	22,956	52,234	8.74	55.1

Table F-10. Rainbow trout fry weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	27,246	23,323	19,401	9.48	75.0
10	31,962	26,131	24,029	11.13	88.1
15	34,693	27,358	26,389	12.03	95.2
20	35,975	28,248	27,212	12.45	98.5
25	36,613	28,417	27,661	12.63	100.0
30	36,556	28,371	27,539	12.61	99.8
35	35,915	28,140	27,007	12.40	98.2
40	35,043	27,500	26,692	12.14	96.1
45	34,069	26,792	26,107	11.82	93.6
50	32,903	25,820	25,520	11.44	90.6
55	31,571	24,530	25,144	11.02	87.3
60	30,308	23,698	24,981	10.68	84.5
65	29,045	22,866	24,819	10.33	81.8
70	27,560	21,736	24,344	9.89	78.3
75	26,151	20,711	23,876	9.47	74.9
80	24,734	19,895	23,589	9.08	71.9
85	23,565	18,993	23,470	8.75	69.3
90	22,579	18,156	23,146	8.45	66.9
95	21,456	17,384	23,055	8.14	64.4
100	20,666	16,625	23,024	7.91	62.6
110	19,144	15,408	22,680	7.46	59.1
120	18,119	14,231	22,607	7.14	56.5
130	17,283	13,335	23,777	7.01	55.5
140	16,400	12,471	23,647	6.74	53.4
150	15,762	11,840	22,339	6.43	50.9
160	14,938	11,256	22,237	6.20	49.1
170	14,299	10,756	21,730	5.98	47.3
180	13,725	10,316	21,857	5.84	46.2
190	13,030	9,825	22,558	5.72	45.3
200	12,487	9,376	23,988	5.71	45.2
250	9,314	8,197	21,314	4.70	37.2
300	6,140	7,017	18,639	3.70	29.3
350	4,578	6,111	18,357	3.27	25.9
400	3,823	5,586	17,443	2.98	23.6
450	3,105	5,375	16,659	2.74	21.7
500	2,589	5,111	15,364	2.49	19.7
600	1,880	4,699	13,256	2.10	16.6
700	1,297	4,383	11,448	1.78	14.1
800	917	4,004	10,061	1.53	12.1
900	688	3,673	8,897	1.34	10.6
1,000	648	3,323	7,632	1.18	9.3

Table F-11. Rainbow trout juvenile weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	8,423	6,860	3,233	2.63	25.7
10	11,537	8,161	5,957	3.64	35.5
15	14,317	9,442	8,089	4.52	44.2
20	16,823	10,721	10,126	5.34	52.2
25	19,218	11,998	12,095	6.13	59.9
30	21,195	13,229	13,700	6.80	66.4
35	22,691	14,386	15,056	7.34	71.7
40	24,148	15,242	16,186	7.82	76.4
45	25,614	16,254	16,788	8.26	80.7
50	26,749	17,122	17,133	8.60	84.0
55	27,675	17,744	17,401	8.87	86.7
60	28,801	18,601	18,100	9.24	90.3
65	29,926	19,458	18,798	9.62	93.9
70	30,656	20,061	18,780	9.81	95.9
75	31,264	20,654	18,598	9.97	97.4
80	31,545	21,321	18,451	10.07	98.4
85	31,944	21,812	18,444	10.20	99.6
90	32,119	22,185	18,158	10.24	100.0
95	31,807	22,474	18,067	10.19	99.6
100	31,542	22,454	18,005	10.13	99.0
110	30,571	22,666	17,552	9.91	96.8
120	29,382	22,347	17,400	9.63	94.0
130	28,366	21,948	18,824	9.53	93.0
140	26,943	21,298	18,501	9.15	89.4
150	25,643	20,705	17,023	8.69	84.9
160	24,168	20,038	17,117	8.34	81.5
170	22,814	19,381	16,657	7.96	77.8
180	21,645	18,824	16,786	7.69	75.1
190	20,457	18,260	17,333	7.46	72.8
200	19,482	17,840	18,014	7.29	71.2
250	16,264	17,065	18,490	6.62	64.6
300	13,045	16,290	18,966	5.95	58.1
350	10,691	15,069	17,268	5.20	50.8
400	9,290	13,494	16,974	4.74	46.3
450	7,897	11,849	17,373	4.36	42.5
500	6,668	10,262	17,305	3.96	38.7
600	4,770	8,511	16,960	3.39	33.1
700	3,781	7,641	15,914	3.01	29.4
800	3,090	7,007	13,823	2.61	25.5
900	2,420	6,726	11,760	2.24	21.9
1,000	1,887	6,434	9,942	1.93	18.9

Table F-12. Rainbow trout adult weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	4,803	5,867	1,123	1.60	17.3
10	5,861	6,378	2,107	1.96	21.2
15	6,841	6,930	3,157	2.31	25.0
20	7,805	7,489	4,250	2.66	28.8
25	8,848	8,086	5,386	3.03	32.9
30	9,830	8,694	6,412	3.39	36.7
35	10,721	9,344	7,366	3.72	40.3
40	11,718	9,920	8,306	4.06	44.0
45	12,730	10,614	9,133	4.41	47.8
50	13,645	11,259	9,857	4.72	51.1
55	14,504	11,859	10,583	5.02	54.4
60	15,369	12,515	11,474	5.34	57.8
65	16,234	13,171	12,364	5.66	61.3
70	17,013	13,769	12,960	5.93	64.2
75	17,775	14,351	13,538	6.19	67.1
80	18,439	14,993	14,175	6.45	69.8
85	19,164	15,529	14,882	6.71	72.7
90	19,890	16,078	15,331	6.95	75.3
95	20,442	16,620	15,873	7.16	77.6
100	21,066	17,057	16,406	7.38	79.9
110	22,189	18,062	17,052	7.76	84.0
120	23,141	18,882	17,690	8.09	87.6
130	24,095	19,710	20,041	8.58	93.0
140	24,653	20,348	20,195	8.77	95.0
150	25,122	20,982	18,902	8.79	95.2
160	25,261	21,458	19,228	8.90	96.3
170	25,313	21,831	18,698	8.89	96.2
180	25,491	22,149	18,923	8.97	97.2
190	25,374	22,249	19,478	9.01	97.6
200	25,326	22,354	20,031	9.07	98.2
250	24,264	22,501	23,781	9.24	100.0
300	23,203	22,649	25,437	9.20	99.6
350	20,498	21,722	27,094	8.73	94.6
400	18,643	20,779	26,882	8.25	89.4
450	16,468	19,876	27,173	7.76	84.1
500	14,476	18,863	26,411	7.20	77.9
600	10,791	16,998	24,897	6.14	66.5
700	8,360	14,899	23,112	5.28	57.2
800	6,640	13,013	21,065	4.57	49.5
900	5,127	11,513	19,763	4.00	43.3
1,000	3,956	10,551	18,710	3.58	38.7

Table F-13. Bull trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)			Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3		
5	3,985	6,035	7,444	2.07	15.7
10	7,683	12,363	15,779	4.20	31.9
15	10,757	18,394	22,058	5.98	45.3
20	12,938	24,281	25,800	7.31	55.4
25	14,491	28,964	28,216	8.28	62.8
30	15,773	32,874	29,744	9.03	68.5
35	16,850	36,235	31,121	9.69	73.5
40	17,629	38,985	32,784	10.25	77.7
45	18,192	40,798	34,255	10.67	80.9
50	18,696	42,160	35,678	11.03	83.7
55	19,232	42,662	36,699	11.29	85.6
60	19,672	44,676	38,977	11.78	89.3
65	20,111	46,690	41,255	12.27	93.1
70	20,424	47,290	42,115	12.47	94.6
75	20,714	47,818	42,709	12.64	95.8
80	20,992	48,976	43,440	12.87	97.6
85	21,450	49,329	43,877	13.03	98.8
90	21,851	49,383	43,689	13.10	99.4
95	22,132	49,323	43,663	13.15	99.7
100	22,427	49,087	43,636	13.19	100.0
110	22,874	48,560	42,858	13.15	99.7
120	23,324	46,995	42,162	13.03	98.9
130	23,770	45,441	42,716	13.04	98.9
140	23,721	43,374	41,697	12.75	96.7
150	23,491	41,297	39,103	12.26	93.0
160	23,000	39,309	38,299	11.90	90.3
170	22,641	37,466	36,647	11.51	87.3
180	22,194	35,560	36,366	11.22	85.1
190	21,591	33,377	36,606	10.93	82.9
200	21,113	31,502	37,342	10.73	81.4
250	18,856	27,461	46,256	10.80	81.9
300	16,599	23,421	50,401	10.39	78.8
350	13,427	21,153	54,547	9.95	75.5
400	10,943	19,846	52,429	9.13	69.2
450	8,883	18,373	49,579	8.30	63.0
500	7,161	17,243	45,352	7.44	56.4
600	4,025	16,081	38,326	6.01	45.6
700	2,185	14,856	33,782	5.08	38.6
800	1,145	13,998	29,095	4.34	32.9
900	624	13,111	23,688	3.62	27.5
1,000	316	11,786	18,393	2.92	22.2

Table F-14. Bull trout fry weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	23,228	23,110	17,585	8.47	94.5
10	24,501	24,458	18,765	8.96	100.0
15	23,567	23,853	17,782	8.63	96.2
20	21,311	21,288	16,553	7.82	87.2
25	19,416	18,482	16,121	7.15	79.7
30	17,364	15,863	16,167	6.50	72.6
35	15,219	13,888	16,200	5.90	65.8
40	13,439	12,225	16,639	5.43	60.6
45	12,170	10,960	16,703	5.07	56.6
50	10,965	9,727	16,839	4.73	52.8
55	9,984	8,707	17,159	4.48	49.9
60	8,692	8,012	15,901	4.03	45.0
65	7,401	7,317	14,644	3.58	40.0
70	6,766	6,934	14,595	3.42	38.1
75	6,211	6,598	14,509	3.27	36.4
80	5,723	6,291	14,574	3.15	35.1
85	5,414	5,958	14,650	3.06	34.2
90	5,177	5,687	14,450	2.97	33.1
95	4,894	5,439	14,403	2.89	32.2
100	4,789	5,166	14,427	2.84	31.7
110	4,505	4,686	14,208	2.72	30.4
120	4,272	4,354	14,092	2.63	29.4
130	4,068	4,044	15,180	2.67	29.8
140	3,909	3,780	15,261	2.63	29.3
150	3,814	3,617	14,625	2.53	28.2
160	3,743	3,488	14,909	2.53	28.2
170	3,772	3,442	14,499	2.49	27.8
180	3,869	3,429	14,864	2.55	28.4
190	3,830	3,415	15,150	2.57	28.6
200	3,812	3,461	13,160	2.37	26.4
250	2,493	3,047	11,171	1.87	20.9
300	1,174	2,632	6,113	1.07	12.0
350	944	2,376	5,426	0.94	10.4
400	761	1,948	4,021	0.72	8.1
450	632	1,661	3,636	0.63	7.1
500	439	1,577	3,348	0.56	6.2
600	316	1,137	2,443	0.41	4.5
700	158	807	2,483	0.35	3.9
800	198	854	2,274	0.34	3.8
900	322	848	1,668	0.30	3.4
1,000	398	1,020	1,237	0.29	3.3

Table F-15. Bull trout juvenile weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft)			Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
	Site 1	Site 2	Site 3		
5	14,456	11,240	4,939	4.40	43.7
10	17,621	12,492	7,431	5.40	53.6
15	20,072	13,508	9,561	6.19	61.4
20	21,924	14,438	11,436	6.83	67.8
25	23,654	15,356	13,130	7.43	73.7
30	24,934	16,188	14,322	7.88	78.2
35	26,093	16,966	15,005	8.25	81.9
40	27,307	17,527	15,670	8.61	85.4
45	28,513	18,266	16,081	8.96	88.9
50	29,466	18,918	16,286	9.23	91.6
55	30,190	19,315	16,497	9.43	93.6
60	30,936	19,915	16,905	9.67	96.0
65	31,682	20,515	17,312	9.92	98.4
70	32,017	20,829	17,315	10.01	99.4
75	32,202	21,049	17,243	10.06	99.9
80	32,097	21,417	17,177	10.07	99.9
85	32,061	21,581	17,184	10.08	100.0
90	31,943	21,703	16,934	10.04	99.6
95	31,510	21,780	16,825	9.95	98.7
100	31,228	21,629	16,743	9.87	97.9
110	30,541	21,537	16,332	9.68	96.1
120	29,786	21,065	16,005	9.46	93.8
130	29,117	20,646	16,809	9.36	92.9
140	28,000	20,054	16,303	9.04	89.7
150	26,701	19,518	14,959	8.59	85.3
160	25,111	18,953	14,816	8.21	81.5
170	23,730	18,421	14,215	7.82	77.6
180	22,527	17,922	14,174	7.53	74.8
190	21,223	17,324	14,423	7.24	71.9
200	20,158	16,800	14,824	7.02	69.7
250	16,746	15,293	15,099	6.22	61.8
300	13,334	13,785	15,375	5.43	53.9
350	10,523	12,164	14,655	4.65	46.1
400	8,573	10,891	14,335	4.11	40.8
450	7,057	9,838	14,342	3.71	36.8
500	5,864	8,923	13,839	3.34	33.1
600	4,210	7,374	12,834	2.77	27.5
700	3,253	6,254	11,521	2.35	23.3
800	2,605	5,627	10,363	2.05	20.3
900	2,086	5,175	9,337	1.80	17.9
1,000	1,719	4,754	8,508	1.61	15.9

Table F-16. Bull trout adult weighted usable area and total habitat area versus discharge relationships for Reach 3; Lostine River, Oregon.

Discharge (cfs)	Weighted Usable Area (sq-ft per 1000 linear ft) Site 1	Site 2	Site 3	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	7,433	7,643	1,046	2.28	34.3
10	8,418	7,950	1,874	2.59	39.0
15	9,208	8,263	2,633	2.85	42.9
20	9,904	8,565	3,374	3.09	46.5
25	10,682	8,890	4,120	3.35	50.4
30	11,375	9,198	4,783	3.58	53.9
35	11,978	9,529	5,407	3.80	57.1
40	12,709	9,788	6,043	4.03	60.6
45	13,456	10,139	6,589	4.26	64.2
50	14,089	10,453	7,006	4.46	67.1
55	14,678	10,727	7,428	4.65	69.9
60	15,287	11,034	7,907	4.84	72.9
65	15,896	11,341	8,386	5.04	75.8
70	16,453	11,606	8,680	5.20	78.3
75	17,002	11,864	8,956	5.37	80.7
80	17,470	12,162	9,247	5.52	83.0
85	18,007	12,396	9,614	5.68	85.5
90	18,533	12,642	9,770	5.82	87.6
95	18,876	12,888	10,007	5.94	89.3
100	19,248	13,062	10,234	6.05	91.0
110	19,845	13,483	10,399	6.22	93.7
120	20,273	13,775	10,593	6.36	95.6
130	20,725	14,062	12,166	6.63	99.7
140	20,825	14,219	12,010	6.65	100.0
150	20,862	14,367	10,801	6.55	98.5
160	20,639	14,423	10,850	6.51	98.0
170	20,354	14,433	10,370	6.41	96.4
180	20,147	14,437	10,426	6.37	95.9
190	19,657	14,334	10,765	6.30	94.8
200	19,206	14,240	11,113	6.23	93.8
250	17,172	13,988	12,528	5.94	89.4
300	15,137	13,737	13,943	5.65	85.0
350	13,101	13,213	13,217	5.12	77.0
400	11,950	12,766	12,940	4.82	72.5
450	10,388	12,148	12,880	4.44	66.8
500	9,131	11,433	12,286	4.07	61.2
600	7,407	10,067	11,026	3.47	52.3
700	6,197	8,618	10,324	3.03	45.6
800	5,246	7,405	9,854	2.69	40.4
900	4,481	6,663	9,320	2.41	36.3
1,000	3,816	6,220	8,707	2.18	32.8

APPENDIX *G*

Weighted Usable Area (WUA) and Total Habitat Area (HA) Versus Flow Relationships for Reach 4

Table G-1. Spring chinook salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	0	0.00	0.0
10	0	0.00	0.0
15	0	0.00	0.0
20	14	0.00	0.2
25	82	0.01	1.4
30	211	0.03	3.6
35	375	0.05	6.4
40	557	0.08	9.4
45	763	0.11	12.9
50	981	0.14	16.6
55	1,178	0.17	19.9
60	1,141	0.17	19.3
65	1,105	0.16	18.7
70	1,276	0.19	21.6
75	1,465	0.21	24.8
80	1,625	0.24	27.5
85	1,803	0.26	30.5
90	1,985	0.29	33.6
95	2,162	0.32	36.6
100	2,359	0.34	39.9
110	2,590	0.38	43.8
120	2,801	0.41	47.4
130	3,029	0.44	51.3
140	3,252	0.47	55.0
150	3,452	0.50	58.4
160	3,627	0.53	61.4
170	3,791	0.55	64.2
180	3,957	0.58	67.0
190	4,118	0.60	69.7
200	4,277	0.62	72.4
250	5,093	0.74	86.2
300	5,908	0.86	100.0
350	5,422	0.79	91.8
400	4,598	0.67	77.8
450	3,805	0.56	64.4
500	2,966	0.43	50.2
600	1,703	0.25	28.8
700	1,083	0.16	18.3
800	719	0.10	12.2
900	344	0.05	5.8
1,000	49	0.01	0.8

Table G-2. Fall chinook salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	8	0.00	0.1
10	45	0.01	0.7
15	76	0.01	1.2
20	106	0.02	1.6
25	165	0.02	2.6
30	268	0.04	4.1
35	438	0.06	6.8
40	655	0.10	10.1
45	865	0.13	13.4
50	1,092	0.16	16.9
55	1,321	0.19	20.4
60	1,334	0.19	20.6
65	1,348	0.20	20.8
70	1,517	0.22	23.4
75	1,700	0.25	26.3
80	1,854	0.27	28.6
85	2,021	0.30	31.2
90	2,189	0.32	33.8
95	2,353	0.34	36.3
100	2,534	0.37	39.1
110	2,854	0.42	44.1
120	3,184	0.47	49.2
130	3,471	0.51	53.6
140	3,667	0.54	56.6
150	3,838	0.56	59.3
160	4,008	0.59	61.9
170	4,179	0.61	64.5
180	4,362	0.64	67.4
190	4,507	0.66	69.6
200	4,623	0.68	71.4
250	5,550	0.81	85.7
300	6,477	0.95	100.0
350	5,529	0.81	85.4
400	4,519	0.66	69.8
450	3,674	0.54	56.7
500	3,239	0.47	50.0
600	2,258	0.33	34.9
700	1,411	0.21	21.8
800	816	0.12	12.6
900	567	0.08	8.8
1,000	393	0.06	6.1

Table G-3. Chinook salmon fry weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	6,857	1.00	42.0
10	10,528	1.54	64.5
15	12,684	1.85	77.7
20	14,048	2.05	86.1
25	14,801	2.16	90.7
30	15,120	2.21	92.7
35	15,454	2.26	94.7
40	15,747	2.30	96.5
45	15,811	2.31	96.9
50	15,760	2.30	96.6
55	15,800	2.31	96.8
60	16,056	2.34	98.4
65	16,312	2.38	100.0
70	16,259	2.37	99.7
75	16,109	2.35	98.7
80	16,315	2.38	100.0
85	16,060	2.35	98.4
90	15,743	2.30	96.5
95	15,503	2.26	95.0
100	15,163	2.21	92.9
110	14,522	2.12	89.0
120	13,759	2.01	84.3
130	13,028	1.90	79.9
140	12,533	1.83	76.8
150	12,063	1.76	73.9
160	11,632	1.70	71.3
170	11,186	1.63	68.6
180	10,755	1.57	65.9
190	10,329	1.51	63.3
200	9,930	1.45	60.9
250	5,467	0.80	33.5
300	3,074	0.45	18.8
350	681	0.10	4.2
400	580	0.08	3.6
450	455	0.07	2.8
500	304	0.04	1.9
600	310	0.05	1.9
700	360	0.05	2.2
800	303	0.04	1.9
900	296	0.04	1.8
1,000	331	0.05	2.0

Table G-4. Chinook salmon juvenile weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	4,235	0.62	21.9
10	7,667	1.12	39.7
15	10,470	1.53	54.2
20	12,876	1.88	66.7
25	14,301	2.09	74.1
30	15,052	2.20	78.0
35	15,497	2.26	80.3
40	15,969	2.33	82.7
45	16,336	2.39	84.6
50	16,753	2.45	86.8
55	17,181	2.51	89.0
60	17,658	2.58	91.5
65	18,134	2.65	93.9
70	18,453	2.70	95.6
75	18,673	2.73	96.7
80	19,184	2.80	99.4
85	19,240	2.81	99.7
90	19,251	2.81	99.7
95	19,302	2.82	100.0
100	19,190	2.80	99.4
110	19,035	2.78	98.6
120	18,688	2.73	96.8
130	18,222	2.66	94.4
140	17,785	2.60	92.1
150	17,319	2.53	89.7
160	16,870	2.46	87.4
170	16,451	2.40	85.2
180	16,145	2.36	83.6
190	15,851	2.31	82.1
200	15,495	2.26	80.3
250	9,074	1.33	47.0
300	5,351	0.78	27.7
350	1,628	0.24	8.4
400	1,169	0.17	6.1
450	932	0.14	4.8
500	714	0.10	3.7
600	371	0.05	1.9
700	305	0.04	1.6
800	315	0.05	1.6
900	242	0.04	1.3
1,000	273	0.04	1.4

Table G-5. Coho salmon spawning weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	161	0.02	2.9
10	421	0.06	7.5
15	732	0.11	13.1
20	1,122	0.16	20.1
25	1,502	0.22	26.9
30	1,792	0.26	32.1
35	2,099	0.31	37.6
40	2,375	0.35	42.6
45	2,608	0.38	46.7
50	2,830	0.41	50.7
55	3,034	0.44	54.4
60	3,173	0.46	56.9
65	3,313	0.48	59.4
70	3,506	0.51	62.8
75	3,697	0.54	66.2
80	3,844	0.56	68.9
85	3,962	0.58	71.0
90	4,060	0.59	72.7
95	4,158	0.61	74.5
100	4,268	0.62	76.5
110	4,468	0.65	80.1
120	4,637	0.68	83.1
130	4,782	0.70	85.7
140	4,933	0.72	88.4
150	5,105	0.75	91.5
160	5,244	0.77	94.0
170	5,359	0.78	96.0
180	5,445	0.80	97.6
190	5,526	0.81	99.0
200	5,581	0.82	100.0
250	4,618	0.67	82.7
300	3,655	0.53	65.5
350	2,873	0.42	51.5
400	2,184	0.32	39.1
450	1,600	0.23	28.7
500	1,116	0.16	20.0
600	449	0.07	8.0
700	279	0.04	5.0
800	185	0.03	3.3
900	89	0.01	1.6
1,000	13	0.00	0.2

Table G-6. Coho salmon fry weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	9,776	1.43	65.9
10	12,499	1.83	84.2
15	13,395	1.96	90.2
20	14,263	2.08	96.1
25	14,842	2.17	100.0
30	14,776	2.16	99.6
35	14,542	2.12	98.0
40	14,230	2.08	95.9
45	13,702	2.00	92.3
50	13,232	1.93	89.1
55	12,866	1.88	86.7
60	12,298	1.80	82.9
65	11,730	1.71	79.0
70	11,236	1.64	75.7
75	10,831	1.58	73.0
80	10,652	1.56	71.8
85	10,282	1.50	69.3
90	9,918	1.45	66.8
95	9,642	1.41	65.0
100	9,331	1.36	62.9
110	8,749	1.28	58.9
120	8,230	1.20	55.5
130	7,696	1.12	51.9
140	7,179	1.05	48.4
150	6,677	0.98	45.0
160	6,226	0.91	41.9
170	5,808	0.85	39.1
180	5,473	0.80	36.9
190	5,163	0.75	34.8
200	4,885	0.71	32.9
250	2,851	0.42	19.2
300	1,719	0.25	11.6
350	586	0.09	4.0
400	548	0.08	3.7
450	511	0.07	3.4
500	558	0.08	3.8
600	546	0.08	3.7
700	509	0.07	3.4
800	545	0.08	3.7
900	555	0.08	3.7
1,000	420	0.06	2.8

Table G-7. Coho salmon juvenile weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	5,874	0.86	30.9
10	9,478	1.38	49.9
15	11,994	1.75	63.1
20	13,995	2.04	73.7
25	15,647	2.29	82.4
30	16,664	2.43	87.7
35	17,263	2.52	90.9
40	17,726	2.59	93.3
45	17,952	2.62	94.5
50	18,067	2.64	95.1
55	18,186	2.66	95.7
60	18,259	2.67	96.1
65	18,332	2.68	96.5
70	18,540	2.71	97.6
75	18,592	2.72	97.9
80	18,994	2.77	100.0
85	18,971	2.77	99.9
90	18,923	2.76	99.6
95	18,934	2.77	99.7
100	18,855	2.75	99.3
110	18,765	2.74	98.8
120	18,579	2.71	97.8
130	18,361	2.68	96.7
140	18,168	2.65	95.7
150	17,947	2.62	94.5
160	17,722	2.59	93.3
170	17,411	2.54	91.7
180	17,031	2.49	89.7
190	16,568	2.42	87.2
200	16,121	2.35	84.9
250	9,339	1.36	49.2
300	5,493	0.80	28.9
350	1,647	0.24	8.7
400	1,082	0.16	5.7
450	871	0.13	4.6
500	729	0.11	3.8
600	569	0.08	3.0
700	548	0.08	2.9
800	527	0.08	2.8
900	482	0.07	2.5
1,000	379	0.06	2.0

Table G-8. Steelhead trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	12	0.00	0.2
10	57	0.01	0.8
15	107	0.02	1.6
20	213	0.03	3.1
25	321	0.05	4.7
30	464	0.07	6.7
35	631	0.09	9.2
40	802	0.12	11.6
45	945	0.14	13.7
50	1,091	0.16	15.8
55	1,240	0.18	18.0
60	1,349	0.20	19.6
65	1,458	0.21	21.1
70	1,578	0.23	22.9
75	1,703	0.25	24.7
80	1,810	0.26	26.2
85	1,919	0.28	27.8
90	2,025	0.30	29.4
95	2,130	0.31	30.9
100	2,243	0.33	32.5
110	2,451	0.36	35.5
120	2,650	0.39	38.4
130	2,841	0.41	41.2
140	3,022	0.44	43.8
150	3,213	0.47	46.6
160	3,398	0.50	49.3
170	3,582	0.52	51.9
180	3,776	0.55	54.8
190	3,926	0.57	56.9
200	4,044	0.59	58.6
250	5,455	0.80	79.1
300	6,866	1.00	99.6
350	6,896	1.01	100.0
400	6,375	0.93	92.4
450	5,474	0.80	79.4
500	4,612	0.67	66.9
600	3,341	0.49	48.4
700	2,471	0.36	35.8
800	1,788	0.26	25.9
900	1,103	0.16	16.0
1,000	580	0.08	8.4

Table G-9. Rainbow trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	0	0.00	0.0
10	0	0.00	0.0
15	0	0.00	0.0
20	9	0.00	0.1
25	52	0.01	0.8
30	118	0.02	1.9
35	189	0.03	3.0
40	267	0.04	4.3
45	348	0.05	5.5
50	430	0.06	6.9
55	506	0.07	8.1
60	505	0.07	8.1
65	504	0.07	8.0
70	582	0.08	9.3
75	667	0.10	10.6
80	738	0.11	11.8
85	819	0.12	13.1
90	905	0.13	14.4
95	989	0.14	15.8
100	1,082	0.16	17.3
110	1,248	0.18	19.9
120	1,434	0.21	22.9
130	1,628	0.24	26.0
140	1,816	0.27	29.0
150	2,014	0.29	32.1
160	2,179	0.32	34.8
170	2,309	0.34	36.8
180	2,439	0.36	38.9
190	2,565	0.37	40.9
200	2,689	0.39	42.9
250	4,267	0.62	68.0
300	5,845	0.85	93.2
350	6,270	0.92	100.0
400	6,193	0.90	98.8
450	5,778	0.84	92.2
500	4,833	0.71	77.1
600	3,158	0.46	50.4
700	2,394	0.35	38.2
800	2,102	0.31	33.5
900	1,403	0.20	22.4
1,000	591	0.09	9.4

Table G-10. Rainbow trout fry weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	15,610	2.28	62.9
10	20,343	2.97	81.9
15	22,662	3.31	91.3
20	24,097	3.52	97.1
25	24,714	3.61	99.5
30	24,828	3.63	100.0
35	24,543	3.58	98.9
40	24,167	3.53	97.3
45	23,541	3.44	94.8
50	22,980	3.36	92.6
55	22,405	3.27	90.2
60	22,083	3.23	88.9
65	21,762	3.18	87.6
70	21,319	3.11	85.9
75	20,918	3.06	84.3
80	20,766	3.03	83.6
85	20,339	2.97	81.9
90	19,940	2.91	80.3
95	19,602	2.86	79.0
100	19,231	2.81	77.5
110	18,472	2.70	74.4
120	17,659	2.58	71.1
130	16,837	2.46	67.8
140	16,129	2.36	65.0
150	15,445	2.26	62.2
160	14,849	2.17	59.8
170	14,299	2.09	57.6
180	13,803	2.02	55.6
190	13,279	1.94	53.5
200	12,818	1.87	51.6
250	7,589	1.11	30.6
300	2,359	0.34	9.5
350	1,823	0.27	7.3
400	1,584	0.23	6.4
450	1,520	0.22	6.1
500	1,359	0.20	5.5
600	1,162	0.17	4.7
700	1,106	0.16	4.5
800	1,097	0.16	4.4
900	920	0.13	3.7
1,000	748	0.11	3.0

Table G-11. Rainbow trout juvenile weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	5,383	0.79	24.7
10	9,934	1.45	45.6
15	13,228	1.93	60.8
20	14,941	2.18	68.6
25	16,408	2.40	75.4
30	17,829	2.60	81.9
35	18,800	2.75	86.3
40	19,563	2.86	89.9
45	19,840	2.90	91.1
50	20,009	2.92	91.9
55	20,220	2.95	92.9
60	20,553	3.00	94.4
65	20,885	3.05	95.9
70	21,098	3.08	96.9
75	21,348	3.12	98.0
80	21,762	3.18	100.0
85	21,773	3.18	100.0
90	21,757	3.18	99.9
95	21,764	3.18	100.0
100	21,601	3.15	99.2
110	21,438	3.13	98.5
120	21,316	3.11	97.9
130	21,182	3.09	97.3
140	21,096	3.08	96.9
150	20,901	3.05	96.0
160	20,646	3.02	94.8
170	20,252	2.96	93.0
180	19,876	2.90	91.3
190	19,476	2.84	89.5
200	19,220	2.81	88.3
250	12,654	1.85	58.1
300	6,087	0.89	28.0
350	4,878	0.71	22.4
400	3,749	0.55	17.2
450	3,053	0.45	14.0
500	2,408	0.35	11.1
600	1,735	0.25	8.0
700	1,102	0.16	5.1
800	992	0.14	4.6
900	875	0.13	4.0
1,000	730	0.11	3.4

Table G-12. Rainbow trout adult weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	1,554	0.23	8.4
10	3,321	0.49	18.0
15	4,888	0.71	26.4
20	6,520	0.95	35.3
25	7,986	1.17	43.2
30	9,190	1.34	49.7
35	10,265	1.50	55.5
40	11,312	1.65	61.2
45	12,152	1.77	65.7
50	12,936	1.89	70.0
55	13,729	2.01	74.3
60	14,429	2.11	78.1
65	15,130	2.21	81.9
70	15,667	2.29	84.8
75	16,113	2.35	87.2
80	16,800	2.45	90.9
85	17,037	2.49	92.2
90	17,182	2.51	93.0
95	17,338	2.53	93.8
100	17,319	2.53	93.7
110	17,454	2.55	94.4
120	17,602	2.57	95.2
130	17,741	2.59	96.0
140	17,966	2.62	97.2
150	18,114	2.65	98.0
160	18,293	2.67	99.0
170	18,371	2.68	99.4
180	18,393	2.69	99.5
190	18,406	2.69	99.6
200	18,482	2.70	100.0
250	15,718	2.30	85.0
300	12,954	1.89	70.1
350	9,993	1.46	54.1
400	7,914	1.16	42.8
450	6,272	0.92	33.9
500	4,962	0.72	26.8
600	3,207	0.47	17.4
700	2,066	0.30	11.2
800	1,569	0.23	8.5
900	1,223	0.18	6.6
1,000	981	0.14	5.3

Table G-13. Bull trout spawning weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	183	0.03	3.1
10	517	0.08	8.8
15	1,080	0.16	18.4
20	1,384	0.20	23.6
25	1,742	0.25	29.6
30	2,054	0.30	34.9
35	2,302	0.34	39.2
40	2,466	0.36	42.0
45	2,623	0.38	44.6
50	2,774	0.41	47.2
55	2,908	0.42	49.5
60	3,164	0.46	53.8
65	3,419	0.50	58.2
70	3,544	0.52	60.3
75	3,687	0.54	62.7
80	3,828	0.56	65.1
85	3,957	0.58	67.3
90	4,049	0.59	68.9
95	4,140	0.60	70.4
100	4,252	0.62	72.4
110	4,463	0.65	75.9
120	4,629	0.68	78.8
130	4,802	0.70	81.7
140	4,955	0.72	84.3
150	5,148	0.75	87.6
160	5,333	0.78	90.7
170	5,492	0.80	93.5
180	5,627	0.82	95.7
190	5,765	0.84	98.1
200	5,876	0.86	100.0
250	4,774	0.70	81.2
300	3,671	0.54	62.5
350	2,893	0.42	49.2
400	2,320	0.34	39.5
450	1,613	0.24	27.4
500	1,080	0.16	18.4
600	369	0.05	6.3
700	178	0.03	3.0
800	66	0.01	1.1
900	0	0.00	0.0
1,000	0	0.00	0.0

Table G-14. Bull trout fry weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	8,805	1.29	59.8
10	11,537	1.68	78.4
15	12,825	1.87	87.1
20	14,218	2.08	96.6
25	14,720	2.15	100.0
30	14,613	2.13	99.3
35	14,334	2.09	97.4
40	14,026	2.05	95.3
45	13,282	1.94	90.2
50	12,601	1.84	85.6
55	12,109	1.77	82.3
60	11,521	1.68	78.3
65	10,932	1.60	74.3
70	10,333	1.51	70.2
75	9,833	1.44	66.8
80	9,582	1.40	65.1
85	9,159	1.34	62.2
90	8,761	1.28	59.5
95	8,463	1.24	57.5
100	8,174	1.19	55.5
110	7,534	1.10	51.2
120	6,924	1.01	47.0
130	6,277	0.92	42.6
140	5,724	0.84	38.9
150	5,224	0.76	35.5
160	4,882	0.71	33.2
170	4,568	0.67	31.0
180	4,288	0.63	29.1
190	3,985	0.58	27.1
200	3,707	0.54	25.2
250	1,944	0.28	13.2
300	181	0.03	1.2
350	157	0.02	1.1
400	94	0.01	0.6
450	104	0.02	0.7
500	125	0.02	0.9
600	228	0.03	1.6
700	299	0.04	2.0
800	341	0.05	2.3
900	405	0.06	2.8
1,000	330	0.05	2.2

Table G-15. Bull trout juvenile weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	8,164	1.19	35.3
10	13,290	1.94	57.4
15	16,213	2.37	70.1
20	18,220	2.66	78.8
25	19,995	2.92	86.4
30	21,110	3.08	91.3
35	21,798	3.18	94.2
40	22,342	3.26	96.6
45	22,550	3.29	97.5
50	22,852	3.34	98.8
55	23,134	3.38	100.0
60	23,124	3.38	100.0
65	23,114	3.38	99.9
70	23,048	3.37	99.6
75	22,938	3.35	99.2
80	23,093	3.37	99.8
85	22,849	3.34	98.8
90	22,619	3.30	97.8
95	22,498	3.29	97.3
100	22,311	3.26	96.4
110	22,010	3.21	95.1
120	21,668	3.16	93.7
130	21,364	3.12	92.4
140	21,092	3.08	91.2
150	20,801	3.04	89.9
160	20,602	3.01	89.1
170	20,370	2.97	88.1
180	20,127	2.94	87.0
190	19,821	2.89	85.7
200	19,513	2.85	84.3
250	13,000	1.90	56.2
300	6,488	0.95	28.0
350	4,599	0.67	19.9
400	3,668	0.54	15.9
450	3,025	0.44	13.1
500	2,590	0.38	11.2
600	2,006	0.29	8.7
700	1,754	0.26	7.6
800	1,495	0.22	6.5
900	1,214	0.18	5.2
1,000	1,070	0.16	4.6

Table G-16. Bull trout adult weighted usable area and total habitat area versus discharge relationships for Reach 4; Lostine River, Oregon.

Discharge (cfs)	Site 1 Weighted Usable Area (sq-ft per 1000 linear ft)	Total Habitat Area for Reach (Acres)	Percent of Maximum for Reach
5	2,095	0.31	12.1
10	4,139	0.60	23.8
15	5,811	0.85	33.4
20	7,449	1.09	42.8
25	8,918	1.30	51.3
30	10,075	1.47	57.9
35	11,105	1.62	63.9
40	12,097	1.77	69.6
45	12,903	1.88	74.2
50	13,581	1.98	78.1
55	14,232	2.08	81.9
60	14,728	2.15	84.7
65	15,224	2.22	87.6
70	15,636	2.28	89.9
75	15,897	2.32	91.4
80	16,461	2.40	94.7
85	16,493	2.41	94.9
90	16,532	2.41	95.1
95	16,630	2.43	95.6
100	16,623	2.43	95.6
110	16,750	2.45	96.3
120	16,900	2.47	97.2
130	17,027	2.49	97.9
140	17,165	2.51	98.7
150	17,188	2.51	98.9
160	17,283	2.52	99.4
170	17,346	2.53	99.8
180	17,386	2.54	100.0
190	17,320	2.53	99.6
200	17,284	2.52	99.4
250	13,154	1.92	75.7
300	9,024	1.32	51.9
350	7,073	1.03	40.7
400	5,677	0.83	32.7
450	4,897	0.72	28.2
500	4,270	0.62	24.6
600	3,271	0.48	18.8
700	2,369	0.35	13.6
800	1,916	0.28	11.0
900	1,420	0.21	8.2
1,000	975	0.14	5.6